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AFML-TR-74-10 Volume II

SLEEVE COLDWORKING FASTENER HOLES

Volume II-Appendixes

Joseph L. Phillips

Manufacturing Research and Development

Boeing Commercial Airplane Company

30% 25 1374 J

TECHNICAL REPORT AFML-TR-74-10, VOLUME II

February 1974

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Air Force Materials Laboratory
Manufacturing Technology Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

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SLEEVE COLDWORKING FASTENER HOLES

Volume II-Appendixes

Joseph L. Phillips

Distribution limited to U.S Government agencies only; test and evaluation data; February 1974. Other requests for this document must be referred to Manufacturing Technology Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio 45433

FOREWORD

This technical report covers all work performed under Contract F33615-72-C-1630 from 1 June 1972 to 30 November 1973. This manuscript was released for publication by the author in February 1974.

This contract with The Boeing Commercial Airplane Company was initiated under Manufacturing Methods Project 746-2, "Sleeve Coldworking Fastener Holes." It was conducted under the technical direction of Captain Carlan Silha, Metals Branch (AFML'LTM), Manufacturing Technology Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio.

This program was accomplished at The Boeing Commercial Airplane Company in Scattle, Washington, with Mr. Richard G. Christner as program manager, Mr. Joseph L. Phillips as principal investigator, and Mr. Ray Hendricks as primary coordinator and director of the testing program. Other personnel that supported the program in Boeing were DeVere Lindli, Dave Reese, Tom Kane, Burke Dykes, Walt Swift, and Merrell Christianson.

Publication of this final technical report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of lideas. You comments are solicited on the potential utilization of the information contained herein as applied to your present and/or future production and/or your maintenance rework. Suggestions concerning additional manufacturing methods on this or other subjects will be appreciated.

This program was accomplished as part of the Air Force Manufacturing Technology Program, the primary objective of which was to develop on a timely basis, manufacturing processes and techniques for use in economical production of USAF materials and components for aircraft production.

This technical report has been reviewed and approved for publication.

H. A. JOHNSON

Chief, Metals Branch

Manufacturing Technology Division

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H. A. JOHNSON

Chief, Metals Branch

Manufacturing Technology Division

ABSTRACT

In this 21-month program, optimized process parameters for sleeve coldworking of fastener holes have been developed, and the effects of process and application parameters on structival performance have been defined for selected aluminum, titanium, and high-strength steel alloys. The sleeve coldworking process for fastener holes is a process that uses a tapered mandrel in conjunction with a disposable, prelubricated sleeve to compressively prestress a significant size zone around each hole which offsets the stress concentration of the hole itself. The sleeve method allows higher degrees of prestressing than possible with other methods and offers potential for significant improvements in fatigue performance. In addition, it does not require precision controls germane to other fatigue-rated hole preparation/fastener installation systems. This technical report covers the results of this 21-month program. In addition to definition of optimized methods and the effects of process and application variations upon structural performance, the results include performance and economics comparisons for the process with other fatigue-rated hole preparation/fastener systems.

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APPENDIX I

MATERIAL PROCUREMENT TEST REPORTS

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PHASE I...TASK I. MANDREL TAPER DETERMINATION

TEST PLATE NUMBER: 1	NOMINAL SIZE 3/8" (-12)	MANDREL MATERIAL: H-II-nitrided MANDREL TAPER. 015 inch/inch	LUBRICATION Fel Pro 300 (on sleeve)	MANDREL DIA. +2xSLEEVE THICKNESS: 3738	COMPOSITION 2024-T851 STACK UP 3/B"
TEST NUMBER: 181	MANDREL ST 5300 CBM-(1-O-N	MAX. DIA. MANDREL 3538" MAND	PULL: X PUSH:	SLEEVE THICKNESS:	TEST MATERIAL: Aluminum COMP

Mid. Bot. Of hole of hole affective of hole and below and b	Š	j az	Size prior to CW*	cw.	Finish prior	Maximum expansion	Si.	Size after C.V.	٨.	Finish	Upset	Upset	Force recurred	Sleeve	exp.	Retained hole expansion (calc.)	le.)
3550 75 0193 3656 3660 - - - 2090 None 0110 0110 3550 3550 55 50 0188 3670 3660 3670 - - 0040° 0055° 1915 None 0110 0110 3550 3550 85 0188 3640 3645 3650 - - - 1730 None 0090 0095 3550 3550 90 0188 3640 3645 3650 - - - - 1730 None 0090 0095 3550 3550 355 3645 3650 - - - - - - - - - 0090 0095 0095 0095 0095 0095 0095 0095 0095 0095 0095 0096 0096 0096 0096 0096 0096 0096 0096 0096 0096	Top		Mid	Bot.	to CW	(calc.)	dot	Mid.	Bot.	after CW	of hale	of hole	for Mandrel	thin out	Тор	Mid.	Bot.
3550 550 50 0118 3670 3660 3670 - 0040° 0055° 1915 None 0125 0110 3550 3550 85 0188 3640 3645 3650 - - 1730 None 0090 0095 3550 3550 85 0188 3640 3645 3650 - - - 1730 None 0090 0095 3550 3550 75 0188 3640 3645 3650 - - - - - 0090 0095 0095 3550 75 0188 3640 3645 3650 - - - - - - - 0090 0095 0095 3550 75 0188 3640 3645 3650 - - - - - - - - - - - - - - -	35.45		35.45		75	0193	3655	3655	3660	1	1	١	2090	None	0110	0110	0110
3550 3550 85 0188 3645 3645 3650 - - 1800 None 0090 0095 3550 3550 3550 36 - - - 1730 None 0090 0095 3550 3550 3550 35 3645 3650 - - - 1765 None 0095 0095 3550 3550 75 0188 3640 3645 3650 - - - 1785 None 0099 0096	3545		3550		20	.0188	3670	3660	3660		.0040	0055	1915	None	0125	0110	0110
3550 3550 90 .0188 3640 3645 40 - - 1730 None 0090 0095 3550 3550 3550 75 .0188 3640 3645 3650 - - - 1765 None 0095 0095 3550 3550 75 .0188 3640 3645 3650 - - - - 1785 None 0090 0095	3550	-	3550	3550	82	.0188	3640	3645	3650	1	!		1800	None	0600	3000 2000 2000	900
3550 3550 85 .0188 3640 3645 3650 1765 None 0095 0095 3550 75 .0188 3640 3645 3650 17785 None 0090 0095	3550	0	3550	3550	- 06	0188	3640	3645	3645	40	i	1	1730	None	D600	2600	9600
3550 3550 75 .0188 3645 3650 1785 None 0090 0095	3545	5	3550	3550	85	.0188	3640	3645	3650				1765	None	5600	9600	0010
	3550	8	3550	3550	75	.0188	3640	3645	3650				1785	None	0600	9600	0100
	}	1															
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	}	1															

To nearest 0.0005 inch

PHASE LITASK L-MANDREL TAPER DETERMINATION

TEST PLATE NUMBER: 1	J.N NOMINAL SIZE 3.8" (-12)	MANDREL MATERIAL: Hall mittided MANDREL TAPER:030 inch/inch	LUBRICATION: Fel Pro 300 (on sleeve)	MANDREL DIA2 SLEEVE THICKNESS 3738	COMPOSITION: 2024-T851 STACK UP: 3/8"
TEST NUMBER: 182	MANDREL ST 5300 CBM-() O.N	MAX, DIA, MANDREL3538"	PU'L: X PUSH:	SLEFVE THICKNESS	TEST MATERIAL Aluminum

\$ T	eot.	0115	9110	.0100	0115	0100	0100		
Retained hole expansion call.	Mid	0110	0110	0100	0110	0600	0600		
Ret	Lop	0100	0100	9600	0115	0600	0600		
Sleere	thin out	None	None	None	None	None	None		
Force required	for Mandrel	1460	1385	1275	1325	1300	1240		
Upset	of hole	ı		 ! :	.0055		0055		
Session of	t hole	į		0040		i	.0040		
Finsh	after CW	•		 	45	:	 		
, Ņ	Sot	3665	3665	3645	3665	3645	3650		
Size after CW*	Mid.	3560	3655	3645	3660	3635	3640		
ZIS	dol	3660	3655	3640	3660	3635	3640		
Maximum	(cate.)	.0188	.0193	.0193	.0188	.0193	.0193		
Finish prior	to CW	85		85	100	82	75		
. 3	Bot.	3550	3555	3545	3550	3545	3550		
Size prior to CW*	Mid.	3550	3£45	3545	3550	3545	3550		
Size	Тор	3560	3545	3545	3545	3545	3550		
Hole	ou	E-1	E-2	F.3	E-4	E-5	E-6		

.045 inch/inch MANDREL TAPER 3/8" (-12) __TEST PLATE NUMBER ___ MANDREI MATERIAL Hill-nitrided NOMINAL SIZE MANDREL ST 5300 CBM-()-O-N TEST NUMBER MAX DIA MANDREL

LUBRICATION Fel Pro 300 (on sleeve) PUSH __ PULL __

MANDREL DIA. +2xSLEEVE THICKNESS 3739" 2024-T851 COMPOSITION: .010 SLEEVE THICKNESS

TEST MATERIAL

3/8..

- STACK UP:

Hole	Size	Size prior to CW*	.wo	Finish prior	Max imum expansion	Size	Size after CW*	. M	Frnish	Upset	Upset	Force	Sleeve	Reta	Retained hole expansion (calc.)	ن آن
	Тэр	Mıd.	Bot	to CW	(calc.)	Тор	Mid	Bot.	after CW	of hole	of hole	for Mandret	thin out	Тор	Mid.	30t.
1-1	3550	3550	3550	09	6810	099£	3660	3670	:		!	1200	None	0110	0110	0120
ω	3545	3545	3550	99	.0194	3640	3640	3645	30	·	i	1110	None	5600	9600	9600
2	3545	3660	3545	. 08	0179	3660	3665	3670	!	.0025	.0900	1245	None	0115	0105	0125
	3545	3545	3545	. 08	0194	3660	3660	3670	ł	:		1235	None	0115	0115	0125
4	3545	3545	3545	82	0194	3640	3640	3645	!	-	; ; ;	1195	None	5600	9600	0100
1-1	3560	3550	3550	35	0189	3660	3660	3665			i	1215	None	0100	0010	0115
							•		· · · · · · · · · · · · · · · · · · ·							
											-					
	-															
) .	To 120, 2000 O 120, 120, 120, 120, 120, 120, 120, 120,	005 tar.b														

TEST PLATE NUMBER:_

5

TEST NUMBER:

ST 5300 CBM () O	MAX. DIA. MANDREL: .3538" MANDREL MATERIAL: H-II-nitrided MANDREL TAPER: .015 inch/inch	PULL: X PUSH: LUBRICATION: Fel Pro 300 (on sleeve)	SLEEVE THICKNESS:O10" MANDREL DIA. +2xSLEEVE THICKNESS:3738"	TEST MATERIAL: Aluminum COMPOSITION: 2024-T851 STACK UP: 3/8"	Size prior to CW* Finish prior expansion CW* Finish of the contraince exit for entrance exit for expansion (calc.)
					Hole

Bot.	0900	0070	3900	0055	0000	00700				
Mid	0900	0900	0900	00.40	0065	9000				
Тор	0900	0900	0020	0040	9000	9000				
thin out	None	None	None	None	None	None				
for Mandrel	1375		1315	1265	1425	1550				
of hole	-	.0035			i	i				
of hole	1	.0015		;	:	į				
after CW	-	1	25	-	i	1				
Bot.	3670	3675	3665	3660	3675	3675				
Mid.	3660	3670	3655	3645	3670	3670				
Тор	3655	3665	3655	3645	3670	3670				
(calc.)	0128	.0128	.0133	.0133	.0133	.0133				
to CW	æ	35	55	75	45	80				
Bot.	3610	3605	3610	3605	3605	3605				
Mid.	3610	3610	3605	3605	3605	3605				
Тор	3615	3605	3605	3605	3605	3605				
Ou	A-1	A2	A-3	A-4	A-5	A-6				
	Top Mid. Bot to CW (calc.) Top Mid. Bot. after CW of hole of hole Mandrel thin out Top Mid.	Top Mid. Bot. to CW (calc.) Top Mid. Bot. after CW of hole of hale for thin out Top Mid.	Top Mid. Bot. Top Mid. Bot. after CW of hole of h	Top Mid. Bot. For Mid. Bot. after CW af	Top Mid. Bot. Top Mid. Bot. after CW after CM and after CW after CM after CW after CW after CM	Top Mid. Bot. after CW After CW of hole of hole for Mandrel Hinn out Top Mid. 3615 3610 3610 50 0128 3655 3660 3670 1375 None 0050 0050 3605 3610 55 0128 3655 3650 3655 3655 1315 None 0050 0050 3605 3605 3605 75 0133 3655 3655 3650 1315 None 0040 0040 3605 3605 3605 75 0133 3670 3670 3675 1265 None 0040 0040 0040	Top Mid. Bot. Top (Mid.) For (about) For (about)	Top Mid. Bot. To CAM Cialc.) Top Mid. Bot. after CAM circles Abouted of hole Abouted of hole Abouted of hole Abouted of hole Thin out Top Mid. 3605 3610 3610 360 365 3665 3670 1375 None 0050 0050 3605 3605 3610 365 3655 3665 3665 25 1315 None 0060 0060 3605 3605 3605 365 3656 3665 25 1315 None 0060 0060 3605 3605 3605 45 0133 3670 3675 11265 None 0065 0065 3605 3605 3605 80 0133 3670 3675 1425 None 0065 0065	Top Mid. Bot. To CW (rale.) Top Alid. Bot. after CW cf hole If hole Hole If hole Hole If hole <th< td=""><td>Top Mid. Bot. Top CW Giffer CW</td></th<>	Top Mid. Bot. Top CW Giffer CW

· Michael Andelick ac

TEST VIJMBER	TEST PLATE NUMBER	
MANUREL ST 5300 CBM ()-O-N	NOMINAL SIZE 3/8' (12)	
MAX DIA MANDREL	MANDREL MATERIAL Hill-nitrided MANDE	MANDREL TAPER 030 inch/inch
PULL X PUSH	LUBRICATION Fel Pro 30	Fel Pro 300 (an sleeve)
SLEEVE THICKNESS 010" MANDREL	MANDREL DIA. +2xSLEEVE THICKNESS3738"	:,
TEST MATERIAL Aluminum COMPOSITIO	COMPOSITION 2024-T851 STACE	STACK UP 3/8"

Retained hole expansion (catc.)	p Mid. Bot.	0000 0000 00	15 0065 0065	15 0045 0055	15 0045 0050	0000 0000	0900 0900 09	15 0045 0055	-
	thin out Top	None 0060	None 0075	None 0045	None 0045	None 6060	None 0060	None 0045	
Force	Mandret	1400	1290	1170	1115	1300	1225	1160	
Upset	of hole		-		0040	: :	! : i		
Upset	of hole	- :-			.0020	Í	, .		
Finish	after CW		50		i	1	!	;	
.W.	Bot.	3670	3665	3660	3655	3675	3665	3660	1
Size after CW	Mid.	3650	3665	3650	3650	3665	3665	3650	: !
S.	Тор	3665	3675	3650	3650	3665	3665	3650	
Maximum	(calc.)	.0138	.0138	0133	0133	0133	0133	=	· · I · · ·
Finish prior	to CW	08	99	45	. 6	52		02	j
cw.	Bot	3600	3600	3605	3605	3605	3605	3605	:
Size prior to CW	ΡiΜ	3600	3620	3635	3605	3605	3605	3605	!
Size	Тэр	3605	3600	3605	3605	3605	3605	3605	-
Hofe	င	A-7	A8	8 -	B-2	B-3	B - 4	B5	

						ole :alc.]	
					í	Retained hole expansion (catc.)	Mid.
		.045 inch/inch	J			Re	Top
1		i			3/8	Sleeve	thin out
		MANDREL TAPER:_	LUBRICATION: Fel Pro 300 (on sleeve)	.3739"	STACK UP:	Force required	for Mar.drel
=	3/8" (-12)	MAN	Fel Pro 30		ST.	Upset	of hole
UMBER.		nitrided	CAFION:	THICKNE	T851	Upset	of hole
TEST PLATE NUMBER.	NOMINAL SIZE	MANDREL MATERIAL: H-II-nitrided	LUBRI	MANDREL DIA. +2xSLEEVE THICKNESS: _	2024-T85	Finish	after CW
TES	ON	MATER		EL DIA.	TION:	. 2	Bot
		ANDREL		MANDRI	COMPOSITION:	Size after CW*	Mid.
53	N-O-()-	ž				žiS	Тор
	ST 5300 CBN),,	PUSH	ESS:010"		Maximum	(catc.)
TEST NUMBER:_	MANDREL ST 5300 CBM-[]-O-N	.3539"	×	SLEEVE THICKNESS:	TEST MATERIAL: Aluminum	Finish prior	to CW
F		ANDRE	PULL	SLE	ERIAL	cw.	Bot.
		MAX. DIA. MANDREL:			EST MAI	Size prior to CW*	Mid.
		MA			F	Size	Тор
						l o	

စ	Size prior to CW*	CW.	Finish prior	Maximum	Š	Size after CW*		Finish	Upset	Upset	Force required	Sleeve	Ret	Retained hole expansion (calc.)	و: او:
Top M	Mid	Bot	to CW	(calc.)	Тор	Mid.	Bot	after CW	of hole	of hole	for Mar.drel	thin out	Top	Mid.	Bot.
<u> </u>	3605	3605	40	.0134	3670	3670	3675	ł 1		-	1120	None	9000	9000	0000
	3605	3605	80	.0134	3670	3670	3675			1	1145	None	9000	900	0010
 / -	3605	3600	6	.0134	3650	3655	3655		1		1025	None	0045	0020	0055
	3605	3605	65	.0134	3665	3665	3675	93	.0030.	.0900	1065	None	0900	0900	0000
 	3605	3605	07	.0134	3655	3655	3655	1	i i		1030	None	0900	0020	0020
†	3605	3605	65	.0134	3670	3670	3675		1	İ	1540	None	900	0065	00700
-															
и															

TEST PLATE NUMBER	NOMINAL SIZE 3/8" (-12)	MANDREL MATERIAL: H-II-nitrided MANDREL TAPER:	LUBRICATION: Fel Pro 300 (on sleeve)	MANDREL DIA, +2×SLEEVE THICKNESS: <u>3738"</u>	COMPOSITION: 2024-T851 STACK UP: 3/8"
TEST NUMBER	MANDREL ST 5300 CBM-()-O-N	MAX DIA MANDREL	PULL X PUSH	SLEEVE THICKNESS 010"	TEST MATERIAL: Aluminum

. j.	Bat.	0025	0035	0030	0025	0035	90035		
Retained hole*expansion (calc.)	Mid.	0020	0035	0030	0020	0030	0030		
Ret	Тор	0020	0035	0030	0020	0030	0600		
Sleeve	thin out	None	None	None	None	None	None		
Force	for Mandret	1235	1275	1260	1045	1200	1190		
Upset	of hole		.0030		1	1			
Upset	of hole	-	00100			l I			
Finish	after CW		1	1	25		i		
	Bot.	3670	3685	3690	3680	3690	3690		
Size after CW*	Mid.	3670	3685	3685	3675	3685	3685		
Siz	Тор	3670	3685	3685	3670	3685	3685		
Maximum	(catc.)	8800	8800	0083	.0083	.0083	.0083		
Finish prior	to CW	20	99	88	8	8	25		
.w.	Bot.	3645	3650	3660	3655	3655	3655		
Size prior to CW*	Mid.	3650	3650	3655	3655	3655	3655		
Size	Тор	3650	3650	3655	3650	3655	3655		
Hole	OL.	E1	E2	E-3	E-4	E-5	E-6		

-		.030 inch/inch			3/8′′
	3/8'' (-12)	MANDREL TAPER:030 inch/inch	LUBRICATION: Fel Pro 300 (on sleeve)	JESS 3738"	STACK UP: 3
TEST PLATE NUMBER:	NOMINAL SIZE	MANDREL MATERIAL: H-II nitrided	LUBRICATION	MANDREL DIA, +2xSLEEVE THICKNESS	COMPOSITION: 2024-T851
102	ST 5300 CBM-()-O-N		PUSH	.010.	
TEST NUMBER:	MANDREL: ST	MAX, DIA, MANDREL: 3538"	PULL: X	SLEEVE THICKNESS:	TEST MATERIAL: Aluminum
		-			

									 · · · · · ·
ote alc.)	Bot.	0020	0030	0020	00:00	0025	0030		
Retained hole expansion (calc.)	Þi _t	9100	0025	0020	0600	0025	0025		
Ret	Тор	0015	0025	9020	0030	0025	0030		
Sleeve	thic out	None	None	None	None	None	None		
Force required	for Nandrel	915	1045	066	1925	1030	995		-
Upset	of hole		-		-	.0030			
Upset	of hole	;	;	!	,	.0005	;		
Finish	after CW	:	i	i	35	1			
>	Bot.	3670	3685	3670	3685	3580	3685		
Size after CW	Mid.	3670	3680	3670	3685	3680	3685		
Sive	Top	3670	3680	3670	3685	3680	3685		
Maximum	(calc.)	8300	0083	0088	.0083	.0083	8200.		
Finish prior	to CW	07	50	20	08	09	99		
, M.	Bot	3650	3655	3650	3650	3655	3655		
Size prior to CW*	Mid.	3650	3655	3650	3655	3655	3660		
Size	do.	3655	3655	3650	3655	3655	3655		
Hoie	5	5-7	8-3	1-1	:-2	-3	4		

PHASF 1.. TASK 1-MANDREL TAPER DETERMINATION

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TEST NUMBER II	MANDREL ST 5300 CBM-(1)-O-N NOMINAL SIZE 3/8" (-12)	IDREL 3539" MANDREL MATERIAL Hilinitrided MANDREL TAPER 045 inch/inch	JUL: X PUSH LUBRICATION Fel Pro 300 (on sleeve)	SLEEVE THICKNESS010" MANDREL DIA. +2xSLEEVE THICKNESS3739".	IAL Aluminum COMPOSITION 2024-T851 STACK UP 3/8"
11		MAX, DIA, MANDREL	PULL:	SLE	TEST MATERIAL _

	Bot.	0050	0030	9700	0050	0030	0030					
hole (calc.)						 	ļ	 		 	! 	
Retained hole expansion (calc.)	Mid	0020	0025	0020	0015	0030	0030			 	ļ -	
ex x	Тор	0000	0025	0025	0015	0030	0030				ļ 	
Sleeve	thin out	None	None	None	None	None	None		} } ! !		 	
Force	for Mandrei	820	950	865	810	096	945					
Upset	of hole					:	9800					
Upset	of hole	!			;		0015					
Finish	after CW	-	!	:	!	35	÷					
W	Bot	3675	3685	3670	3670	3685	3685	i		 	i	
Size after CW*	Mid	3675	3680	3670	3670	3685	3685					
Siz	lop	3675	3680	3675	3670	3685	3685			i	i	
Maximum	(calc.)	.0084	.0084	.0089	.0084	.0084	.0084					
Finish prior	to CW	55	09	209	40	02	75			1	i	
CW.	Bot	3655	3655	3645	3650	3655	3655					1
Size prior to CW*	Mid.	3655	3655	3650	3655	3655	3655					1
Size	Top	3655	3655	3650	3655	3655	3655					18
Hole		F-5	ñ - 6	F 7	e, L	61	2 5					

To rearest 0.0005 inch

TEST PLATE NUMBER:

T NUMBER. TEST PLATE NUMBER: 120 ANDREL ST 5300 CEM-(1-0-N NOMINAL SIZE 3/8" (-12)	MAX, DIA, MANDREL: 3538 MANDREL MATERIAL: H. H. mandrel MANDREL TAPER: U. B. mandrel MAX, DIA, MAX, DIA, MANDREL TAPER: U. B. mandrel MAX, DIA, MAX, DIA	SLEEVE THICKNESS:	TEST MATERIAL STACK UP: 1:1/2" COMPOSITION 2024-T851 STACK UP: 1:1/2"
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Hole	Size	Size prior to CW*	CW.	Finish prior	Махітінен	Size	Size after CW*	, k	Funish	Upset	Upset	Force	Sleeve	Ret	Retained hole expansion (calc.)	e . !c.)
Ç.	Top	Mid	But	to CW	expansion (calc.)	Top	Mid.	Bot.	after CW	of hote	ajou ja	for Mandrel	thin out	Τορ	latet.	B.rt.
- - 5	3540	3545	3545	45	.0193	3685	3680	3680	20		1	3500	Mone	0145	0135	0:35
C2	3540	3545	3545	 	.0193	3685	3675	3680	:	0030	0070	3365	Morre	0145	0130	2135
C-3	3540	3545	3540		.0193	3685	3665	3670	i i	,	:	3370	None	0145	0120	9125
C-4	3540	3540	3540	: : : : : : :	.0198	3685	3680	3685			i	3185	None	0145	0135	0145
C-5	3540	3540	3545	 	0198	3590	3680	3685	i			3200	None	0150	0135	0140
									-							
1.0	To oparest 0 0005 inch	005														

PHASE I.-TASK I.-MANDREL TAPER DETERMINATION

		.030 inch/inch			1.1/2"
11;	3/8" (.12)	MANDREL TAPER	Fel Pro 300 (on sleeve)	SS: .3738"	STACK UP: 1-1
TEST PLATE NUMBER	O-N NOMINAL SIZE	MANDREL MATERIAL H.II.nitrided	LUBRICATION	MANDREL DIA. +2xSLEEVE THICKNESS:	COMPOSITION 2024-T851
TEST NUMBER	WANDREL ST 5300 CBM-()-O-N	MAX DIA MANDREL 3538"	PULL X PUSH:	SLEEVE THICKNESS010"	TEST MATERIAL Aluminum

Size		Size prior to CW	CW	Finish prior	Maximum	S/\S	Size after CW		Finish	Upset	Upset	Force required	Steeve	Rel	Retained hole expansion (calc.)	ن. از:
Top Mid.			Bot	to CW	(catc.)	Тор	Mid.	Bot.	after CW	of hole	of hole	for Mandrel	לוח מולז	Тор	Mid.	Bot.
3540 3550	3550		3540	, ,	0188	3685	3675	3680	i	١	1	2810	None	0145	0125	0140
3545 3540	3540		3540	. !	0198	3690	3680	3665	i	1	0000	2640	None	0145	0140	0125
3540 3545	3545		3545	40	.0193	3690	3680	3665	15	i	-	2550	None	0145	0135	0120
3540 3540	3540	_	3545		0198	3685	3685	3680	i	1	-	2785	None	0145	0140	0135
3540 3540	354(3545	_	0198	3685	3675	3665	ı	0600	.0045	2815	None	0145	0135	0125
					•											
		1														
																
		ı ——														
		1											i i			
*To nearest 0.0005 inch	05 inc	Ę														

1F3 5300 CBM-()-O-N M PUSH:	IF3	ST 5300 CBM ()-O-N NOMINA MANDREL MATERIAL] 	SLEEVE THICKNESS: 010" Nom. MANDREL DIA: +2xSLEEVE THICKNESS: 3739"	TEST MATERIAL STACK UP 1-1/2"
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	Bot.	55	<u>ن</u> آ	35	52	45				
hote.		0150	0145	0135	0125	0145			 	<u></u>
Retained hole expansion (nate.)	Stad.	0140	0135	0140	0125	0140		 		
exp exp	Top	0150	0155	0155	0145	0155				
Sleeve	thin out	None	None	None	None	None	I			_
Force	ror Mandrel	2360	2450	2475	2225	2455				
Upset	of hole		ì	.0045	1	l			-	
Upset	of hole		1	.0030	ì	1				
Finith	after CW	15	1	1	!	l				
	Bot.	3690	3685	3680	3665	3685				
Size after CW	Mid.	3680	3680	3680	3665	3680	 			
Size	Тор	3690	3695	3695	3685	3690				
Maximum	(calc.)	.0159	.0194	.0199	.0199	.0199				
Finish prior	to CW	30	ţ	ļ	i	l				
, ,	Bot.	3540	3540	3545	3540	3540				
Size prior to CW	Mid.	3540	3545	3540	3540	3540				
Size	Тор	3540	3540	3540	3540	3540				
Hole	.00	D.4	D.5	9.0	D-7	8-0	 			

		.015 inch/inch			.1/2
111	3/8" (-12)	MANDREL TAPER 015 inch/inch	LUBRICATION: Fel Pro 300 (on sleeve)	:SS:3738"	STACK UP: 1.1/2"
_TEST PLATE NUMBER:	NOMINAL SIZE:	MANDREL MATERIAL: H-II-nitrided	LUBRICATION	DIA. +2×SLEEVE THICKNE	IN: 2024-T851
61	ST 5300 CBM-()-O-N	MANDREL MA	PUSH	SLEEVE THICKNESS:	COMPOSITION
TEST NUMBER: 1G1	MANDREL: ST 5	MAX. DIA. MANDREL: .3538"	PULL	SLEEVE THICKNESS:	TEST MATERIAL Aluminum
		MAX			TES

									-	 7
le.	Bot.	0000	0000	9500	0075	0/00	9500			
Retained hole expansion (calc.)	Mid.	0900	0050	0050	90065	0900	5900			
edxa exba	Тор	5/00	0055	9900	0000	0900	0/00			
Sleeve	thin out	None	None	None	None	None	None	1		
Force required	tor Mandret	2525	2485	2385	2565	2375	2500			
Upset	of hole	1	1	ı	.0045	1	ı			
Upset	of hole		I	١	06000	ı	ı			
Finish	after CW	1	10	1	ı	ı	١			
. >	Bot.	3690	3690	3675	3695	3690	3675			1
Size after CW*	Mid.	3680	3670	3670	3685	3680	3685			
Size	Top	3695	3675	3675	3690	3680	0690			
Maximum	(calc.)	.0118	.0118	.0118	.0118	.0118	8110.			
Finish prior	to CW	ı	25	1	l	1	l			
.w.	Bot	3620	3620	3620	3620	3620	3620			1
S ze prior to CW*	Mid	3620	3620	3620	3620	3620	3620			
Sze	Top	3620	3620	3620	3620	3620	3620			
Hole	ē	F.3	4	5.	Α. O	F.7	F-8			1

TEST PLATE NUMBER: 111	N NOMINAL SIZE: 3/8" (-12)	MANDREL MATERIAL H-II-nitrided MANDREL TAPER: .030 inch/inch	LUBRICATION: Fet Pro 330 (on sleeve)	MANDREL DIA. +2xSLEEVE THICKNESS: 3738"	COMPOSITION: 2024-T851 STACK UP 1-1/2"
TEST NUMBER: 1G2	MANDREL: ST 5300 CBM-()-O-N	MAX. DIA. MANDREL:3538"	PULL: X PUSH:	SLEEVE THICKNESS:010"	TEST MATERIAL: Aluminum

, ,		·						 	 	1
le.)	Bot	0900	0075	0000	0900	0000				
Retained hole expansion (calc.)	Mid.	0045	9000	90065	9000	0045				
Ret	Top	0900	0000	0000	0/00	9900				
Steere	thin our	None	None	None	None	None				
Force	for Mandrel	1855	2070	1965	1710	1990				
Upset ex:1	of hole	.0045	· · ·	1	1	ı				
Upset	of hole	0030	١	1	١	1				
Firish	after CW	!	١	ţ	20	1				
,,	Bot.	3680	3695	3690	3670	0696				
Size after CW	Mid.	3665	3685	3685	3685	3665				
Size	Тор	3680	3690	3690	3690	3675				
Махітит	(calc.)	.0188	3110.	.0118	.0118	.0118				
Finish prior	to CW	ł		-	45	ŀ				7
.×	Bot.	3620	3620	3620	3620	3620				1
Size prior to CW*	Mid	3620	3620	3620	3620	3620				1
Size	Top	3620	3620	3620	3620	3620	1			1
Hole	e E	E-6	E.7	E-8	1.7	F-2				

To nearest 0.0005 inch

		.045 inch/inch			1-1/2"
131	3/8" (-12)	MANDREL TAPER	LUBRICATION: Fel Pro 300 (on sleeve)	NESS: 3739"	STACK UP
TEST PLATE NUMBER:	NOMINAL SIZE:	MANDREL MATERIAL: H-11-nitrided	LUBRICATION	MANDREL DIA. +2xSLEEVE THICKNESS: 3739"	COMPOSITION 2024-T851
TEST NUMBER: IG3	MANDREL: ST 5300 CBM-()-O-N	MAX. DIA. MANDREL 3539" MAN	PULL: X PUSH:	SLEEVE THICKNESS:	TEST MATERIAL Aluminum CO
		Ş			

in i	CW* Funish	ze after CW"	Maximum Size after CW*	Size after CW	Finish prior expansion Size after CW* to CW	o C(W* Finish prior expansion to CW* to CW*
	Bot.	-+	Mid. Bot.	(calc.) Top Mid. Bot.	(calc.) Top Mid. Bot.	(calc.) Top Mid. Bot.
8	3695		3670 3695	0119 3680 3670 3695	.0119 3680 3670 3695	35 .0119 3680 3670 3695
١ ،	3675		.0119 3695 3675	.0119 3695 3675	3695 3675	0119 3695 3675
. !	3675	3675	.0119 3695 3670 3675	.0119 3695 3670 3675	36200119 3695 3670 3675	36200119 3695 3670 3675
i,	3675		3670 3675	3695 3670 3675	36200119 3695 3670 3675	0119 3695 3670 3675
,	3690		.0119 3695 3690 3690	.0119 3695 3690 3690	3695 3690 3690	0119 3695 3690 3690
! !						
!						
i						
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PHASS (-) ASK L MANDREL TAPER DETERMINATION

						, o (i.i.	Bot.	0020	0900	003-)	0035	0035		
					,	Returned hole (expansion calc.)	Mid	0045	0045	0035	0030	0035		
		t/inch	ı			Ret.	Top	0900	0900	0035	0035	0040		
i		2 .015 incl			1.1/2"	Sleeve	thin out	None	None	None	None	None		
		WANDREL TAPER: .015 inch/inch	Fel Pro 300 (on sleeve)	. 1	STACK UP:	Force	for Mandrei	1750	2060	1165	1380	1240		
Ξ	3/8" (-12)	MANE	Fel Pro 30	.3738"	STA	1350,)	of hote	1	1	ł	{	.0045		
IMBER:		htrided	LUBRICATION:	THICKME	3514	Upset	of hole	:		1	ļ	.0020		
TEST PLATE MUMBER	NOMINAL SIZE	MANDREL MATERIAL: H. D. nimided	- LUBRI	MANDREL DIA. +2xSLEEVE THICKMESS	2C24.T851	Finsh	after CW	10	١	ì				
TES	NOA	MATER		EL DIA.	TON		.deat.	3700	3705	3680	3685	3685		
		ANDREL		MANDRE	COMPOSITION	Sze after CW	Mad.	3698	3695	3685	3680	3685		
-	NO1	- W		1	3	33	Top	3700	3700	3685	3685	3690		
Ξ:	ST 5300 CBM-(1-0-N		PUSH	SS010". Nom.		Maximum	(cafe.)	8800	.0088	8800.	8800	8900		
RESTAUMBER	MANDREC	.3538"	×	SLEEVE THICKNESS	Aluminum	Finish prior	to CW	16	ì	,	ł	ı		
¥.	•	ANOREI	PULL	SLEI	ERIAL	. 64	Вот	3650	3650	3650	3650	3650		
		MAX, DIA, MANDREL			TEST MATERIAL:	Size prior to CW	Mid	3650	3650	3650	3650	3650		
		MAX			<u> </u>	Size	dot	3650	3650	3650	3650	3650		
						Hole	ű. Ö	G-1	6.2	6-3	6.4	6-5		

To nearest 9,0005 inch

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				۲	TEST NUMBER:	IHZ			TE\$	TEST PLATE NUMBER:	UMBER:	Ξ					
					MANDREL:	ST 5300 CBM-()-O-N	N-O-()-N		ō N	NOMINAL SIZE:	ļ	3/8" (-12)					
		MAX	C. DIA. A	MAX. DIA. MANDREL		.3538"	Š !	ANDREI	L MATER	MANDREL MATERIAL: H-11-nitrided	nitrided	MAN	MANDREL TAPER:		.030 inch/inch		
				PULL:	×	PUSH				LUBRI	LUBRICATION:	1	Fel Pro 300 (on sleeve)		•		
				SLE	SLEEVE THICKNESS:	.SS: .010" Nom.	Nom.	MANDE	3EL DIA.	MANDREL DIA. +2xSLEEVE THICKNESS:	: THICKNE		3738"				
		ŢĒ	ST MAT	TEST MATERIAL:_		Aluminum	3	COMPOSITION: -	TION: -	2024-T851		STA	STACK UP:	1-1/2"		1	
L ±	Hole	Size	Size prior to CW	. MO	Finish prior	Maximum	Šiš	Size after CW*	. %	Finish	Upset	Upset	Force	Sieeve	Het Pedxa	Retained hole expansion (calc.)	, <u>o</u>
č 	Ę	Top	M id.	Bot.	to CW	expansion (calc.)	Тор	Mid	Bot.	after CW	of hole	of hole	for Mandrel	thin out	Тор	Mid.	Bot.
g9		3650	3650	3650	20	8800	3705	3692	3700	10		1	}	None	9500	0045	900
G-7	 	3650	3650	3650	-	8800	3700	3680	3685	i	-		1240	None	0020	0030	0036
6-8	-	3650	3650	3650		.0088	3685	3680	3685		.0015	5 600.	1160	None	0035	0030	003
I.	 	3650	3650	3650	91	.0088	3685	3685	3705	-			1360	None	0035	0035	900
Н 2		3650	3650	3650	1	8800.	3700	3695	3685	-			1195	None	0020	0045	003
T E		3650	3650	3650	-	.0088	3700	3695	3685	1	1	}	1195	None	0900	0045	903
	-																
	-																
	-																
F	o near	rest 0.00	To nearest 0.0005 inch														

and the second of the second of the second s

						. î	Bot.	0035	0035	0055	0035	0900			
						Retained hole expansion (calc.)	Mid.	0030	0030	0045	0030	0045			
		.045 inch/inch	;			Reta	Top	0040	0035	0055	0035	0920			
. 1					1-1/2	Sleeve	thin out	None	None	None	Nane	None			
		MANDREL TAPER:	(on sleeve)	.3739"	STACK UP:	Force	for Mandret	975	930	1150	925	1200			
=	3/8" (-12)	MANC	LUBRICATION: Fel Pro 300 (on sleeve)		STA	Upset	of hole		0035	;	i	!			
UMBER:		itrided	CATION: _	THICKNE	51	Upset	of hole	.0015	:	:	-	-			
TEST PLATE NUMBER:	NOMINAL SIZE:	MANDREL MATERIAL: H-II-nitrided	LUBRI	MANDREL DIA. +2xSLEEVE THICKNESS:	2024-T851	Finish	after CW	15	-	: -		-			
TES	NON	MATER		EL DIA.	TION:	.>	Bot	3685	3685	3700	3685	3700			
	-	ANDREL		MANDR	COMPOSITION: _	Size after CW	Mid.	3680	3680	3692	3680	3692			
IH3	5300 CBM-()-O-N	¥.		:	5	Siz	Тор	3690	3685	3705	3685	3700			
	ST 5300 CB	.3539"	PUSH:	.SS:	W.	Maximum	(calc.)	6800	.0089	6800°	6800.	6800			
TEST NUMBER:	MANDREL		×	SLEEVE THICKNESS:	Aluminum	<u></u>	to CW	40	l I	1					
TE	_	MAX, DIA, MANDREL	PULL	SLEE	ERIAL	, A.C	Bot	3650	3650	3650	3650	3650			
		C. DIA. M			TEST MATERIAL	Size prior to C.W*	Mid	3650	3650	3650	3650	3650			
		MA			31	Size	Top	3650	3650	3650	3650	3650			
						Flore	JO.	H4	H-5	ų. I	H-7	H-8			

To nearest 0.0005 inch

TEST NUMBER: 131	MANDREL ST 5300 CBM-()-O-N NOMINAL SIZE 3/4" (-24)	MAX. DIA. MANDREL: 7163" MANDREL MATERIAL: H.II-nitrided MANDREL TAPER: .020 inch/inch	PULL X PUSH: LUBRICATION: Fel Pro 300 (on sleeve)	SLEEVE THICKNESS:	MATERIAL: Aluminum COMPC 1110N 2024:T851 STACK 1JP: 2.50"
		MAX. DIA. MANDE	PULL	S	TEST MATERIAL:

Hole	Size	Size prior to CW*	. MO	Finish prior	Maximum	Size	Size after CW	. ^	Finish	Upset	Upset	Force	Steeve	Ret	Retained hole expansion (calc.)	e . Ic.)
)	Top	Mid	Bot	to CW	(calc.)	Top	Mid	Bot.	after CW	of hole	of hole	for Mandrel	thin out	Тор	Mid.	Вот.
													5000			
8-3	7145	7140	7140	40	.0323	7355	7320	7350	, !	_	1	22,250	typ	0210	0180	0210
8.4	7145	7140	7140	20	.0323	7350	7320	7355	i	1	ı	20,580	.0005′′ typ	0205	0180	0215
- 5	7146	7140	İ	5	0323	7355	7325	7340	2	0900	0600	18.340	.0005"	0210	0185	0195
5		3		3		?	2	2	2				0000			
C:2	7145	7140	7140	40	.0323	7355	7325	7340	ţ	1	1	15,800	typ	0210	0185	0200
ç3	7145,	7140	7140	40	.0323	7355	7320	7340	i		1	18,400	.0005" typ	0210	0180	0020
							i	!	 - - -							
								1								
15.0	1. To on 1995	One inch														

PHASE I-TASK I-MANDREL TAPER DETERMINATION

					· 6.	Eof.	0235	6240	0240	0235	0230		
					Retained hole expansion (cult.)	Vard.	0205	0190	0185	0020	0195		
	.030 inch/inch	1			He12 exper	Top }	0225	0220	0225	0235	0230		
TEST NUMBER: V MANDREL ST 5300 CBM-(1-O-N NOMINAL SIZE: 3/4" (-24) MAX DIA, MANDREL TAPER:		G		1-1/8″	Steeve	thio out	i		ı	I	l		
İ	DREL TAPE	Fet Pro 500 (on sleeve)	7465"	STACK UP:	pammas eom	tor Mandrel	096'6	10.070	10,100	10,180	10,330		
>	1.24	Fel Pro 3	Ì	STA	Upset	of hole	0/00	!	1	· - ·	i		
UMBER	1 51	LUBRICATION	THICKNE	1851	Upset	of hole	0025	ı	-	i	l		
T PLATE N			MANDREL DIA. •2×SLEEVE THICKNESS	2024-1851	Firsh	after CW		l	:6	l	I		
ANDREL ST 5300 CBM-(1-0-N NOMINAL SIZE:			EL DIA.	NOIL	, >	Bot.	7365	7370	7370	7365	7360		
			MANDRI	COMPOSITION	Size after CW*	Di@	7335	7320	7315	7330	7330		
	i.().0-hi			ا	Siz	ľep	7360	7350	7360	7370	7365		
	ST 5300 CBN	PUSH:	.SS: .015"		ដូច្នេក	(Calc.)	.0335		.0335	0335	.0330		
T NUMBER:			SLEEVE THICKNESS:	Aluminum	Finish prior	10 CW	1	;	8.10	 	-		
16	ANDREL	PULL	SLEI	ERIAL:_		Bot	7130	7130	7130	7130	7130		
	DIA			TEST MATERIAL:	Size prior to CW*	Mid.	7130	7130	7130	7130	7135		
	₽ XAX			ਘ }- :	Size	Top	7135	7130	7135	7135	7135		
					Hole	С	C-4	D-1	0.2	D.3	D.4		

のできます。

To nearest 0.0005 inch

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		.045 inch/inch			.1/8
TEST PLATE NUMBER: VI	NOMINAL SIZE: 3/4" (-24)	MANDREL MATERIAL Hil-nitrided MANDREL TAPER:045 inch/inch	LUBRICATION: Fel Pro 300 (on sleeve)	MANDREL DIA. +2xSLEEVE THICKNESS:7465"	COMPOSITION: 2024-T851 STACK UP: 1-1/8"
TEST NUMBER: 1J3	MANDREL ST 5300 CBM-()-O-N	MAX, DIA, MANDREL:7165"	PULL: X PUSH:	SLEEVE THICKNESS: .015"	TEST MATERIAL: Aluminum

Hole	Size	Size prior to CW*	, MO	Finish prior	Maximum	Size	Size after CW	٠,	Finish	Upset	Upset	Force	Sieeve	Retexpa	Retained hole expansion (calc.)	.; (.)
Ŋ.	Тор	Mic	Bc	r- CW	(caic.)	Top	Mid.	Bot.	after CW	of hole	of hole	for Mandrel	thin out	Тор	Mid.	Вот.
C:4	7135	7135	7140	1	0330	7335	7325	7355	1		l	7700	1	0220	0100	0215
D-1	7135	7130	7130	1	.0335	7370	7350	7340	1	i	1	7260	-	0235	0220	0210
D.2	7135	7135	7130	-	.0330	7360	7345	7340	1	.0030	.0095	8080	l	0225	0210	0210
0-3	7130	7130	7130	20.25	.0335	7365	7335	7345	10	í	١	8200	1	0235	0205	0215
D-4	7135	7130	7130	-	.0335	7360	7325	7360	ı	ı	ı	0998	l	0225	0185	0230
		1														
To ne	*To nearest 0.0005 inch	005 inch														

						. 7	Bot.	0195	0200	0225	0200	0190	0195			
	٠.,	ļ				Retained hole* expansion (calc.)	Mid.	0140	0150	0145	0140	0135	0140	 		
		.020 inch/inch				Retai	Top	0185	0185	0190	0185	0175	0185			
		1			2.50"	Sleeve	thin out	None	None	None	None	None	None			
≥		MANDREL TAPER:	Fel Pro 300 (on sleeve)	3	STACK UP:	Force	for Mandrel	13,020	11,900	11,440	11,260	11,020	13,080			
	3/4" (-24)	MAND	1	.7463"	STAC	Upset	of hole	ı		0800		1				
UMBER:		H-II-nitrided	LUBRICATION: _	E THICKNE	158	Upset	of hote	ı	1	.0650	1	1	1			
TEST PLATE NUMBER:	NOMINAL SIZE		LUBRI	MANDREL DIA. +2xSLEEVE THICKNESS:	2024-T851	Finish	after CW		1	25	ı	l	1			
TES	NON	MANDREL MATERIAL:		EL DIA.	ION:		Bot	7390	7395	7420	7395	7385	7390			
		NOREL		MANDR	COMPOSITION	Size after CW*	Mid.	7340	7350	7345	7340	7335	7340			
	N 0 1	ž	}	:0	3 	Size	Top	7390	7390	7395	7390	7380	7390			
IK1	ST 5300 CBM-()-O N		PUSH	SS		Maximum	(calc.)	.0263	.0263	.0263	.0263	.0263	.0263			
TEST NUMBER	MANDREL	.7163"	×	SLEEVE THICKNESS:	Aluminum	Finish prior	to CW	120	09	98	70	40	40			
1.6	~	ANDREL	PULL	SLEE	BIAL		Bot.	7195	7195	7.95	7195	7195	7195			
		MAX, DIA, MANDREL:			TEST MATERIAL	Size prior to CW*	Mid.	7200	7200	7200	7200	7200	7200			05 inch
		MAX			Ţ	Size	Top	7205	7205	7205	7205	7205	7205			To nearest 0.0005 inch
						Hole	ē	A 1-4	A:2	A-3	A-4	1.9	8-2			To neg

PHASE 1-TASK I-MANDREL TAPER DETERMINATION

					(.)	Bot.	0170	0175	0175	0160	0185	0185	-	
				1	Retained hole expansion (calc.)	Mid.	0130	0150	0145	0135	0140	0145		
	.030 inch/inch	ı			Reta	Тор	0165	0175	0110	0170	0175	0185		
1		, ,		1.1/8"	Sleeve	thin out	,	1	ı	I	ı	,		
	MANDREL TAPER	Fel Pro 300 (on sleeve/	32.	STACK UP:	Force	for Mandrei	8270	8270	8260	7860	7800	7760		
>		Fel Pro 3	.7 465 "	STA	Upset	alou jo	;	:	1	l	5900	l		
IUMBER:	ZE 3/4" (-24) H-11-nitrided	LUBRICATION: -	MANDREL DIA. +2xSLEEVE THICKNESS:	851	Upset	of hole		i	,	!	.0025			
TEST PLATE NUMBER:	14.51	LUBR	2×SLEEVE	2024-T851	Finish	after CW	1	5	1	l	l	l		
TES	NOMINA MANDREL MATERIAL:		EL DIA.	TION		Bot.	7360	7370	7370	7370	7380	7380		
	ANDREL		MANDRE	COMPOSITION	Size after CW*	Mid.	7330	7345	7340	7330	7335	7340		
	1-()-O-N			ت 	Size	Тор	7360	7370	7365	7365	7370	7380		
IK2	ST 5300 CBM-{ 1.O-N	PUSH:	.015		Maximum	(calc.)	.0265	.0270	.0270	.0270	.0270	.0270		-
TEST NUMBER	MANDREL:	×	SLEEVE THICKNESS:	Aluminum	Finish prior	to CW	1	8.10	_	1	I	8.10		
Ŧ	ANDREL	PULL	SLEI	ERIAL:_	. %	Bot	7190	7195	7195	7190	7195	7195		
	MA MAX CIA, MANDREL:_			TEST MATERIAL:_	Size prior to CW	Mid.	7200	7195	7195	7195	7195	7195		
	MAX			TE	Size	Тор	7195	7195	7195	7195	7195	7195		
					Hole	JO J	A.1	A-2	A-3	A-4	181	B-2		

To nearest 0.0005 inch

PHASE I. TASK I. MANOREL TAPER DETERMINATION

	.045 inch/inch			
S. 1K3	MANDREL MATERIAL Hitchicked MANDREL TAPER.	PULL: X PUSH: LURRICATION Fel Pro 300 (on sloeve)	SLEEVE THICKNESS	Aluminin COMPOSITION 2024-T551 STACK UP 1-1/8"
	MAX, DIA, MANDREL 7165	PU:.:	S	TEST MATERIAL

COMPOSITION

TEST MATERIAL

ا د نو	Bot.	0155	1 2 1	9:75	0170	0190	0180			
Retainas note:	Sid	0120	0145	0145	0120	0145	0145			
exb :	Тор	0166	0175	0175	0165	0180	0185			
Sterve	the out	ı	;	i	1	,	l			
Force	for familiei	7500	0929	0999	6320	9809	6200			
Upset 9×11	`	!	1	.0600	- 1	1				
Unset	alou l		!	.002:5	;	!	!			
First	afte CA	1 :	1	ហ	1	1	1			
	So*.	7360	7365	7365	7360	7385	7375			
Size after CW	Mind	7335	7340	7340	7335	7345	7340			
SIZ	160	7370	7370	7370	7365	7375	7380			
May made	(care)	.0250	:		0520	.0265	0220			
Funch jaron	to CE	i	; ;			I				
. 78	 .:	7195	7190	7190	7190	7195	7195			
Size prior to CW*	Mid.	7215	7195	7195	7215	7200	7195			
3-7-S	Top	7210	7195	7195	7200	7195	7195			
Hole	ę	A.1	A-2	A-3	A-4	8.1	8.2			

PHASE I-TASK I-MANDREL TAPER DETERMINATION

		.020 inch/inch			
NUMBER: IV	NOMINAL SIZE: 3/4" (-24)	1-II-nitrided MANDREL TAPER:	LUBRICATION: Fel Pro 300 (on sleeve)	VE THICKNESS: 7463"	2024-T851 STACK UP: 2.50"
TEST PLATE NUMBER:	ST 5300 CBM-()-O-N NOMINAL SI	MANDREL MATERIAL: H-II-nitrided	PUSH:	15" MANDREL DIA. +2x5LEEVE THICKNESS:	COMPOSITION: 2024
TEST NUMBER: IL1	MANDREL: ST 5300	MAX. DIA. MANDREL: 7163"	PULL: X PU	SLEEVE THICKNESS: 015"	TEST MATERIAL . Aluminum

									 	_
le sic.)	Bot.	0130	0130	0140	0140	0135	1			
Retained hole expansion (calc.)	Mid.	0100	0600	0085	900	0600				
Ret expa	Тор	0145	0150	0155	0150	0135				
Sleeve	thin out	.0005′′ typ	0005." typ	.0005" typ	.0005" typ	.0005" typ	ļ			
Force required	for Mandrel	10,200	9,440	8,740	ı	1				
Upset	of hole	ı	1	1	5700.	١				
Upset	of hole	1	1	١	.0035	1				
Finish	after CW		1	1	5	-				
,	Bot.	7380	7380	7385	7385	7380				
Size after CW*	Mid.	7350	7340	7335	7345	7335				
Size	Тор	7395	7400	7405	7400	7385				
Maximum	(calc.)	.0213	.0213	.0213	.0213	.0218				
Finish prior	to CW	\$	8	æ	04	30				
.×	Bot	7250	7250	7245	7245	7245				
Size prior to CW*	Mid.	7250	7250	7250	7250	7245				
Size	Top	7250	7250	7250	7250	7250				
Hole	ō.	2	1-9	0.5	0.3	0.4				
	_							1	 	

PHASE I. TASK I. MANDREL TAPER DETERMINATION

						. (;	Bot.	0140
					ı	Retained hole * expansion (calc.)	Mid.	0110 0110
		ch/inch	ì			Ret	Top	0140
1		.030 in			1.1/8″	Sleeve	thin out	1
		MANDREL TAPER 030 inch/inch	Fet Pro 300 (on sleeve)	2	STACK UP:	Force	for Mandrel	6440
>	-24)	MAN	ł	ESS .746	,TS	Upset	of hole	1
UMBER	NOMINAL SIZE 3/4" (-24)	H-II-nitrided	LUBRICATION -	MANDREL DIA. + 2 × SLEEVE THICKNESS	-	Upset	of hole	-
TEST PLATE NUMBER	MINAL SIZE	-	LUBR	+ 2 × SLEE	2024.T851	Finish	after CW	1
TES	Š.	MANDREL MATERIAL		EL DIA.	TION	.×	Bot.	7380
	z	ANDREL		MANDR	COMPOSITION	Size after CW"	Mid	7350
	M.().0	2		1		Sız	do1	7380
11.2	ST 5300 CBM-()-O-N		PUSH		£	Maximum	(calc)	.0225
TEST NUMBER	MANDREL	MAX DIA MANDREL	X	SLEEVE THICKNESS:	Aluminum	Finish prior	Io CW	1
4	-	ANDRE	PULL	SLEI	ERIAL:_	.M	Bot	7240
		. ola M			TEST MATERIAL.	Size prior to CW*	Mic	7240
		MAX			TE	Size	Тор	7240

	Bot.	9	ñ	9	9	.6						
ole calc.)	ĕ	0140	0145	0150	0120	0150		ļ 		ļ	<u></u>	
Retained hole * expansion (calc.)	Mid.	0110	0100	0125	0120	0110						
Re exp	Top	0140	0135	0145	0140	0145						
Sleeve	thin out	١	1	1	ı	ı						
Force required	for Mandrel	6440	6260	6160	6150	6250						
Upset	of hole	-	1	1	.0055							
Upset	of hole	-	1	-	5100.	ı	~ <u>-</u>					
Finish	after CW	1	1	1	ر ا	i						
. >	Bot.	7380	7380	7385	7385	7385						
Size after CW"	Mid.	7350	7340	7355	7355	7350						
Size	top	7380	7375	7385	7380	7385				-		
Maximum	(calc)	.0225	.0225	.0230	.0230	.0225						
Finish prior	to CW	1		 	8-10	ı						
, M.	Bot	7240	7235	7225	7235	7235						
Size prior to CW*	Mic	7240	7240	7235	7235	7240			 -			35 inch
Size	Тор	7240	7240	7240	7240	7240						To nearest 0 0005 inch
Hofe	00	B-3	8 4	3	C 5	ဗ္ဗ						To nea

PHASE I-TASK I.-MANDREL TAPER DETERMINATION

		.045 inch/inch			8/.
VI	3/4" (.12)	MANDREL TAPER:	LUBRICATION: Fel Pro 300 (on sleeve)	SS: .7465	STACK UP. 1.1/8"
TEST PLATE NUMBER	NOMINAL SIZE 3/4"	MANDREL MATERIAL: Hill-nitrided	LUBRICATION	MANDREL DIA. +2xSLEEVE THICKNESS: 7465	NO. 2024-T851
3	ST 5300 CBM-()-O-N	MANDREL M	PUSH	.015" MANDREL	COMPOSITION
TEST NUMBER: IL3	MANDREL: ST 53	MAX. DIA. MANDREL	PULL: X	SLEEVE THICKNESS:	TEST MATERIAL: Aluminum

	Bot.	0125	0130	0130	0130	0130			
hole (calc.)	ě						 	 	 1
Retained hole expansion (calc.)	Mid	0110	0110	0105	c105	0115	 		
Re	Тор	0140	0140	0145	0135	0145			
Sieeve	thin out	-		١	!	١			
Force	for Mandret	5240	5300	5220	5360	5290			
Upset	of hole			9900	;		i		
Upset	of hole	1	i	.0020	1	l			
Finish	after CW	10	l j	1		l		1	
	Bot.	7365	7370	7365	7370	7365			
Size after CW*	Mid.	7350	7350	7245	7345	7.50			
Size	Top	7380	7380	7370	7375	7380			
Maximum	(calc.1	.0225	.0225	0225	.0225	.0230			
Finish prior	to CW	20	1	i i	1	1			
·,	Bot	7240	7240	7235	7240	7235			1
Size prior to CW*	Mid.	7240	7240	7240	7240	7235			
Size	Top	7240	7240	.235	7240	7235			
Hole	ō.	B:3	B.4	5	C:2	င္ပိ			1

PHASE I - TASK I-MANDREL TAPER DETERMINATION

0115 0110 0100 Bot. 0105 0105 expansion (calc.) Retained hote 0085 9600 0095 0100 0095 Mid. MANDREL TAPER: 0.015 inch/inch Top 0105 0105 0105 0105 0600 Steeve thin out 3/8 inch 00100 00100 00100 0000 00100 Fel Pro 300 (on sleeve) Mandrel required Force STACK UP: fo 2190 2190 2270 2275 2235 MANDREL DIA. + 2 x SLEEVE THICKNESS: 0.3738 inch 3/8-inch (-12) of hote Upset exit 0020 1 i ı 1 ₹ LUBRICATION: _ Upset entrance of hole TEST PLATE NUMBER: .0045 MANDREL MATERIAL: H-II-nitrided 1 1 1 NOMINAL SIZE: 6AI-4V Finish after CW 20 1 ţ İ i 3660 3660 3670 3665 3655 Bot. COMPOSITION: Size after CW* 3650 3655 3650 3640 3650 Mid ST 5300 CBM-()-O-N 3660 3660 3660 3645 3660 Top SLEEVE THICKNESS: 0.010 inch PUSH: Maximum expansion **1A1T** .0168 .0166 .0165 .0165 .0165 (calc.) 9,3538 inch TEST NUMBER: MANDRELL Finish prior to CW Titanium 40 ì ! 1 × 1 MAX. DIA. MANDREL TEST MATERIAL: PULL 3555 3555 3555 3555 3555 Bot. Size prior to CW* 3555 3555 3555 3555 3555 Mid. 3555 Cop 3555 3555 3555 3555 A Fole 2 A Ö 83 ដ El

Mandrel diameter progressively reduced to 0.3531 inch in 5 holes

To nearest 0.0005 inch

PHASE I-TASK I.: MANDREI, TAPER DETERMINATION

						<u></u>	-	7		·			···		*****	-	// - m	
						بة أو . يد م	Bot.	0110	9050	0105	0116	0105				<u> </u>		1
					1	Retained hole	Mid	0100	9600	9009	900	9000						-
		h/inch	1	ı		Ret	Lop	0110	0105	0105	0105	0105	, 4.					İ
1		MANDREL TAPER 0.030 inch/inch	(a		3/8 inch	Sleeve	thin out	0100.	.0010	0100	00100	0100						
***************************************		DREL TAPE	Fei Pro 300 (on sleeve)	38 inch	STACK UP:	Force	for Mandret	1720	1670	1615	1770	1660						
\ \ \	3/8 inch (12)	MAN	Fel Pro	JESS: 0.37	STA	Upset	exit of hole	l	ı	.0052	1							
UNBERG.	1	H-II-nitrided	LUBRICATION	VE THICKN		Upset	of hole		i	.0048		!						5 holes
TEST PLATE NUMBER	NOMINAL SIZE	IAL: H-II.	LUBR	+ 2 x SLEEVE THICKNESS: 0.3738 inch	6AI-4V	Finish	after CW	1	ļ			10				-		3531 inch i
168	NO	MANDREL MATERIAL:	ļ		TION	. >	Bot.	3665	3660	3660	3665	3560			; ; ;			Leed to 0
		ANDREL		MANDREL DIA	COMPOSITION	Size after CW	Mid	3655	3650	3650	3650	3650						vely red
	N-O-(W	·		Ö	Size	Гор	3665	3660	3660	3660	3660	!		 			progressi
1.427	1 5300 CBM-	4:	PUSH	SS. 0.010 inc		Maximum	(calc.)	.0168	.0166	.0165	.0165	.0165						Mandrel diameter progressively reduced to 0.3531 inch in 5 holes
TEST NUMBER	MANDREL ST 5300 CBM-()-0-1	0.3538 inch	×	SLEEVE THICKNESS. 0.010 inch	Titanium	Finish prior	to CW		1	ı	ı	25						₽ W
Ξ	-	ANDREL	PULL	SLEE	ERIAL	, _M	Bot.	3555	3555	3555	3555	3555						
		MAX DIA MANDREL			TEST MATERIAL:.	Size prior to CW*	Mid	3555	3555	3555	3555	3555						5 inch
					TE	Size	Гор	3555	3555	3555	3555	3555						To nearest 0.0005 inch
		Δ				Hole	S.	E	G1	H	A2	82						To nea
										الصحبب				l				1

PHASE I-TASK I-MANDREL TAPER DETERMINATION

							Bot.	0105	0105	0110	0105	0105			
					ı	Retained hole expansion (calc.)	Mid.	9000	0100	5600	9600	9600			
		ch/inch	1			Ret	Тор	9010	0105	5600	0105	0105			
1		R. 0.045 in	6		3/8 inch	Sleeve	thin out	.0010	.0010	.0010	0100.	.0010			
	.12)	MANDREL TAPER: 0.045 inch/inch	Fel Pro 300 (on sleeve)	inch.	STACK UP:	Force required	for Mandrei	1635	1425	1440	1400	1435			
- N	3/8 inch (-12)	MAN	Fel Pro 3	ESS:0.373	STA	Upset	of hole	1	ı	I	1	0.0054			
UMBER:		nitrided	LUBRICATION:_	'E THICKN		Upset	of hole	!	1	1	ı	0.005			ľ
TEST PLATE NUMBER:	NOMINAL SIZE:	MANDREL MATERIAL: H-II-nitrided	LUBRI	MANDREL DIA. + 2 x SLEEVE THICKNESS: 0.3739 inch.	6AI-4V	Finish	after CW	1	1	12	1	1			
TES	ON	MATER		EL DIA. 4	TION:	5	Bot.	3660	3660	3665	3660	3660			
		ANDREL		MANDRE	COMPOSITION:	Size after CW	Mid.	3650	3655	3650	3650	3650			
	N-O-()-	W/	l		ŏ 	Size	Тор	3660	3660	3650	3660	3660			
1A3T	ST 5300 CBM-()-O-N	£.	PUSH	.SS. 0.010 incl		Maximum	(calc.)	.0172	.0172	.0172	.0172	.0172			
TEST NUMBER:	MANOREL:	0.3539 inch	×	SLEEVE THICKNESS: 0.010 inch	Titanium	Finish prior	to CW	1	_	30	1	I			
16	n."	MAX. DIA. MANDREL:_	PULL:	SLEE	ERIAL:_	<u>`</u> ≥	Bot.	3555	3555	3555	3555	3555			·
		DIA. M			TEST MATERIAL:	Size prior to CW*	Mid.	3555	3555	3555	3555	3555			
		MAX			TE	Size	Тор	3555	3555	3555	3555	3555			
		Δ	ì			Hole		ಜ	20	E2	F2	62			

Mandrel diameter progressively reduced to 0.3537 inch in 5 holes

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PHASE I TASK I MANDREL TAPER DETERMINATION

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	•	/inch			
		R. 0.015 inch			3/8 inch
VII	(-12)	MANDREL TAPER: 0.015 inch/inch	Fel Pro 300 (on sleeve)	ESS: 0.3731 inch	STACK UP
TEST PLATE NUMBER VII	NOMINAL SIZE 3/8 inch (-12)	A. H.II-nitrided	LUBRICATION:_	2 × SLEEVE THICKN	6A1-4V
531		MANDREL MATER		MANDREL DIA	COMPOSITION
Мы! н	{	531 inch	PUSH	ICKNESS 0.010 inch	ınium
TEST NU	MARUDE	MAX DIA MANDREL 0.3	PULL	SLEFVE TH	TEST MATERIALTita
	MARTHER ST 5300 CBM-(1)-O-N NOMINAL	MANDREL MA	MSH	SLEEVE THICKNESS 0.010 inch MANDREL DIA. + 2 x SLEEVE THICKNESS: 0.3731 inch	Titanium

Hale	Size	Size prior to CW	CW.	Finish prior	Maximum	Size	Size after CW?		Finish	Upset	Upset	Force	Sleeve	- Ret	Retained hole expansion (calc.)	le i
no	Top	Mid	Bot	to CW	(calc.)	Тор	Mid	Bot	after CW	of hote	of hole	for Mandrel	thin out	Тор	Mid	Bot.
A3	3600	3600	3600	_	.0126	3998	3665	3670		ı	l	1925	5000	5900	9900	0000
В3	3600	3600	3600	20	.0126	3660	3655	3665	10	l	ļ	1930	.0005	0900	9900	9000
ස	3600	3600	3600	i i	.0126	3660	3650	3665	1	.0020	.0024	1880	5000	0900	3900	900
03	3600	3600	3600		.0126	3660	3660	3665	l	!	1	1835	.0005	0900	0900	900
£3	3600	3600	3600	1	0126	3670	3660	3670	ļ	l	l	1780	.0005	0000	0900	0000
						! 					 					
						i .										
										1						
-																
1	1 con 3000 0 con con col	005 .000														

PHASE I .- TASK I - MANDREL TAPER DETERMINATION

TEST NUMBER: VIII	MANDREL ST 5300 CBM-().O.N NOMINAL SIZE 3/8 incn (-12)	MAX. DIA. MANDREL 0.3531 inch MANDREL MATERIAL: H-II-nitrided MANDREL TAPER: 0.030 inch/inch	PULL: X PUSH: LUBRICATION: Fel Pro 300 (on sleeve)	SLEEVE THICKNESS 0.010 inch MANDREL DIA + 2 x SLEEVE THICKNESS: 0.3731 inch	TEST MATERIAL Titanium COMPOSITION: 6AL4V STACK UP: 3/8 inch
TEST NUM	MANDRE	MAX. DIA. MANDREL 0.35	Natural Natura Natur	SLEEVE THI	TEST MATERIAL TITAL

Stre after CW Finish Offset Choice Ch				Γ								1 1200	Force		Re	Retained hole	le.
Top Mid. Bot. after CW of hole of hole Mid. Hole Top Mid.	ō	Finish prior	Finish prior		Maxim	E 5	Size	after C	۸.	Finish	Opset	Cpset	required	Sleeve	exb	nsion (c	alc.)
3660 3665 1460 .0005 0060 0060 3655 3665 .0021 .0025 1400 .0005 0060 0065 3660 3670 - 1420 .0005 0065 0060 3660 3665 12 - 1440 .0005 0065 0060 3660 3665 12 - - 1440 .0005 0065 0060	Top Mrd. Bot. to CW (catc.)	Bot. to CW	to CW		(catc.)		Тор	Mid.	Bot.	after CW	of hote	of hoie	tor Mandrel	thin out	Top	Mid.	Bot.
3655 3665 - .0021 .0025 1400 .0005 0060 0065 3660 3670 - - - - 1420 .0005 0065 0060 3660 3665 - - - - 1440 .0005 0065 0060 3660 3665 12 - - 1440 .0005 0065 0060 3660 3665 12 - - 1440 .0005 0065 0060	3600 3600 - 0121	3600	ì		.0121		3660	3660	3665	1	ł	1	1460	.0005	0900	0900	900
3660 3670 - - - 1420 .0005 0065 0060 3660 3665 - - - 1390 .0005 0065 0060 3660 3665 12 - - 1440 .0005 0065 0060 1 1 - - - - - - - 1 1 - - - - - - 1 1 - - - - - - 1 1 - - - - - - - 1 1 - - - - - - - - 1 1 - - - - - - - - - 1 1 -	3600 3600 36000121	3600			.0121		3600	3655	3665	-	.0021	.0025	1400	.0005	0900	0055	900
3660 3665 - - - 1390 .0005 0065 0060 3660 3665 12 - - 1440 .0005 0065 0060 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 <t< td=""><td>3600 36000121</td><td>3600</td><td>1</td><td></td><td>.012</td><td></td><td>3665</td><td>3660</td><td>3670</td><td>ı</td><td>ı</td><td>I</td><td>1420</td><td>.0005</td><td>900</td><td>0900</td><td>0000</td></t<>	3600 36000121	3600	1		.012		3665	3660	3670	ı	ı	I	1420	.0005	900	0900	0000
3660 3665 12 1440 .0005 0065 0060	3600 36000121	3600	1		.0121		3665	3660	3665	١		ı	1390	5000	900	0900	900
	3600 3600 3600 25 .0121	3600 25 .01	25 .01	10.	.0121		3665	3660	3665	12	-	1	1440	.0005	900	0900	900

PHASE 1 - TASK 1 MANDREL TAPER DETERMINATION

		1			d hole" n (calc.)	d Bot.	0000 09	900 09	9900 0900	0900 0900	0065 0070			
	(cu/incm			Retained hole expansion (calc.)	Top Mid	0900 5900	0065 0060	900	00 5900	0000		 	
j		R 0.045 if		3/8 inch	Sieeve	thin out	5000:	.0005	.0005	.0005	.0005			
		MANDREL TAPER: U.045 incn/incn Fel Pro 300 (on sleeve)	7 inch	STACK UP:	Force	for Mandrel	1255	1245	1300	1255	1215			1
117	3/8 inch (-12)	Fel Pro	VESS-0.373	ST.	Upset	of hole	i	0026	l	1	ı			
NUMBER _	E 3/8 inc	H-II-nitrided	VE THICK!		Upset	of hole	1	.0023	1	1	1	}	 	
TEST PLATE NUMBER	NOMINAL SIZE	MANDREL MATERIAL: H-II-nitrided	MANDREL DIA. + 2 x SLEEVE THICKNESS 0.3737 inch	6AI-4V	Finish	after CW	١	l	80	1	ı		!	
TES	ON	L MATER	EL DIA.	TION:	. M	Bot.	3670	3665	3665	3665	3670			
		ANDRE	MANDR	COMPOSITION:	Size after CW	Mid.	3660	3660	366.0	3660	3665	i	!	
	N-O-()-	, }	5		S.2	Тор	3665	3665	3665	3665	3670	!	! ! !	
1837	ST 5300 CBM-()-O-N	PUSH	Ö		Maximum	(calc.)	.0132	.0132	.0132	.0132	.0132	:	:	
TEST NUMBER	ANDREL:	0.3537 inch X	SLEEVE ¶HICKNESS	Titanium	Finish prior	to CW	ı	1	50		1		†	
9	_ !	ANDREI PULL	SLE	ERIAL	. 7.	Bot	3600	3600	3600	3600	3600	:	} } :	
		MAX DIA MANDREL. PULL		TEST MATERIAL	Size prior to CW	Mid	3600	3600	3600	3600	3600			
	:	(₹ ₩		16	Sıze	Top	3600	3600	3600	3600	3600]
					Hole	ê	2	40	E4	F4	64			

PHASE I-TASK I- MANDREL TAPER DETERMINATION

						. 7	Bot.	0030	0025	0030	0030	0030			
		1				Retained hole expansion (calc.)	Mid.	9700	0020	90025	0025	9200			
		ch/inch	,			Reta	Top	90025	0000	0025	0025	9200			
1		R 0.015 in			3/8 inch	Sleeve	thin out	None	None	None	None	None			
		MANDREL TAPER 0.015 inch/inch	Fel Pro 300 (on sleeve)	inch	STACK UP:	Force	for Mandrei	1440	1320	1375	1285	1300			
- N	h (-12)	MANI	Fel Pro 3	ESS: 0.3731	STA	Upset	of hole	-	.0025	_	ı	-			
UMBER	3/8 inch (·12)	nitrided	LUBRICATION: _	E THICKN		Upset	of hole	_	.0020	1	-	ı			
TEST PLATE NUMBER:	NOMINAL SIZE	MANDREL MATERIAL Hill-nitrided	LUBRI	MANDREL DIA. + 2 × SLEEVE THICKNESS: 0.3731 inch	6A1-4V	Finish	after CW	1	10	ſ	-	ı			
TES	NON	MATER		EL DIA.	TION:	.>	Bot.	3690	3685	3690	3690	0696			
		ANDREL		MANDRE	COMPOSITION:	Size after CW*	Mid	3685	3680	3685	3685	3685			
	N-O-()-	Š			3	Size	Jop	3685	3680	3685	3685	3685			
101	ST 5300 CBM-()-O-N	ء	PUSH	SS. 0.010 incl		Maximum	(calc.)	1200.	1200.	1200.	1200.	1200.			
TEST NUMBER	MANDREL:	MAX, DIA, MANDREL: 0.3531 inch	×	SLEEVE THICKNESS: 0.010 inch	Titanium	Finish prior	to CW	ì	20	1	ŀ	1			
116	2	ANDREL	PULL	SLEE	ERIAL:	. 70	Bot.	3660	3660	3660	3660	3660			
		DIA.M			TEST MATERIAL:	Size prior to CW*	Mid	3660	3660	3660	3660	3660			
		MAX			TE	Size	Top	3660	3660	3660	3660	3660			
						Hole	Ē	AS	P5	cs	05	E5			

PHASE I. TASK I. MANDREL TAPER DETERMINATION

A CONTRACTOR OF THE STATE OF TH

NUMBER 1C2T TEST PLATE NUMBER: VII	IDREL ST 5300 CBM-(1-0.N NOMINIAL SIZE 3/8 inch (-12)	nch MANDREL MA	Y Fel Pro 300 (on sleeve)	THICKNESS 0.010 inch MANDREL DIA. + 2 x SLEEVE THICKNESS 0.3731 inch	Titanium COMPOSITION: 6AI-4V STACK UP 3/8 inch
TEST NUMBER 1C2T	MANDREL ST 5300 CBM-	MAX DIA MANDREL 0.3531 inch	PULL X PUSH	SLEEVE THICKNESS: 0.010 inch	TEST MATERIAL Titanium

. ~	Bot.	0030	0030	0030	0025	0030					
Retained hole expansion (calc.)	Mid.	0025	0025 (0025 (0025 (90055					
Reta	Тор	0025	90025	9700	9200	0025		 			
Sleeve	thin out	None	Norie	None	None	None					
Force	for Mandret	1100	1080	1125	1105	1105					
Upset	of hole	1	.0026		1	 			}		
Upset	of hole	١	.0020	ı		1		 			
Finish	after CW	l	!	88	1	1	:	 			
-	Bot.	3690	3690	3690	3685	3690	; ;				
Size after CW*	Mid	3685	3685	3685	3685	3685	† i ! !				
Siz	Top	3685	3685	3685	3685	3685	! !				
Maximum	(calc.)	1,000.	1.00.	1.000.	.007	1.00.					
Finish prior	to CW	1	1	20		 	 	 † · · · · · · · · · · · · · · · · · · ·			
٠,٨	Bot.	3660	3660	3650	3660	3660					
Size prior to CW*	Mid.	3660	3660	3660	3660	3660					O5 inch
Size	Tup	3660	3660	3660	3660	3660					To nearest 0.0005 inch
Hole	8	F5	GS	H5	A6	B6	:				To nea

PHASE I-TASK I: MANDREL TAPER DETERMINATION

							—-т								1		1
					le.)	Bot	0030	0030	0030	0030	00030		· · · · · · · · · · · · · · · · · · ·				
				1	sined ho	Mid.	0025	0025	0025	0025	0025						
	ch/inch	1			Reta	Top	9200	0030	0025	0030	0025						
	R 0.045 ir			3/8 inch	Sleeve	thin out	None	None	None	None	None						
	REL TAPE	00 (on sleeve	7 inch	CK UP:	Force	for Mandrel	1040	1030	1000	985	1020						
h (-12)	MANE	- 1	ESS: 0.373	STA(Upset	of hole	1	ı	.0027	1	1						
3/8 inch	nitrided	CATION: -	/E THICKN		Upset	of hole	-	i	.0023	I	-						
IINAL SIZE	IAL H-II-	LUBR	· 2 × SLEE	6AI-4V	Finish	after CW	î	ı	10	1	ı						
NON	MATER		EL DIA.	TION		Bot.	3690	3690	3690	3690	3690						
	NOREL		MANDRE	OMPOSI.	after CV	Mid.	3685	3685	3685	3685	3685						
N-O-()	W			ت ا	Size	Top	3685	3690	3685	069£	3685						
ST 5300 CBM.	=	PUSH			Maximum	(calc.)	7.00.	7200.	7.00.	7200.	7200.						
- 1	- 1	×	EVE THICKNE	Titanium	Finish prior	Io CW	l	1	20	1	1						
2	ANDREL	PULL	SLEE	ERIAL	.W.	Bot	3660	3660	3660	3660	3660						
	DIA. M.			ST MATE	wior to C	Mid	3660	3660	3660	3660	3660						05 inch
	MAX			1E	Sizer	Top	3660	3660	3660	3660	3660						To nearest 0.0005 inch
					Hole	o O	ક	90	E6	F6	99		-				To ne
	inch (-12	ST 5300 CBM-()-O-N NOMINAL SIZE-	ANDREL: ST 5300 CBM-()-O-N 0.3537 inch X PUSH. NOMINAL SIZE: 3/8 inch [-12]	ANDREL: ST 5300 CBM-()-O-N 0.3537 inch X PUSH. H-II-nitrided LUBRICATION: Fel IUBRICATION: Fel MANDREL DIA: + 2 × SLEEVE THICKNESS:	ANDREL: ST 5300 CBM-()-O-N 0.3537 inch X PUSH. Titanium COMPOSITION: ANDREL MATERIAL H-II-nitrided LUBRICATION: Fel COMPOSITION: 6AI-4V 6AI-4V	MANDREL: ST 5300 CBM-(1)-O-N MAX DIA, MANDREL: 0.3537 inch PULL: X PUSH. LUBRICATION: Fel SLEEVE THICKNESS: 0.010 inch TEST MATERIAL: Titanium COMPOSITION Size after CW: Finish prior Size after CW: Finish Digital Composition Size	MAX DIA, MANDREL: ST 5300 CBM-()-O-N MANDREL MATERIAL H-II-nitrided MANDREL TAPER: 0.045 inch/inch PULL: X PUSH. SLEEVE THICKNESS: 0.010 inch MAXIMUM Size after CW Finish Prior CWY Finish Prior CWY Finish Prior CWY (acalc.) Top Mid. Bot. Bot. Bot. Bot. Bot. Bot. Bot. Bot	MANDREL: ST 5300 CBM-()-O-N NOMINAL SIZE: 3/8 inch (-12) MANDREL: O.3537 inch MANDREL MATERIAL H-II-nitrided MANDREL TAPER: 0.045 inch/inch PULL: X PUSH: LUBRICATION: Fel Pro 300 (on sleeve) LUBRICATION: Fel Pro 300 (on sleeve) SIZE EVE THICKNESS: 0.010 inch MANDREL DIA: 2 × SLEE VE THICKNESS: 0.3737 inch SIZE EVE THICKNESS: 0.010 inch MANDREL DIA: 2 × SLEE VE THICKNESS: 0.3737 inch SIZE EVE THICKNESS: 0.010 inch GAI4V STACK UP: 3/8 inch A SIZE ALL CW FINISh Upset FORCE Retained hole TOP Mid. Bot. FINISh Of hole of hole Of hole of hole Of hole of hole None Retained hole 3660 3660 Of hole of hole Of hole of hole of hole Of hole of hole of hole of hole of hole of hole of hole of hole of hole of hole of hole of hole of hole	MANDREL: ST 5300 CBM·() O·M NOMINAL SIZE: 3/8 inch (-12) MAX DIA, MANDREL: 0.3537 inch MANDREL MATERIAL H·II-nitrided MANDREL TAPER: 0.045 inch/inch TEST MATERIAL: X PUSH. LUBRICATION: Fel Pro 300 (on sleeve) SLEEVE THICKNESS: 0.010 inch MANDREL DIA + 2 x SLEEVE THICKNESS: 0.3737 inch 3/8 inch SLEEVE THICKNESS: MAXIMUM Size after CW* Finish CAMPOSITION Finish Upset Force exit Store Retained hole Size prior to CW* Finish Mid. Bot Finish Of hole Of hol	MAX DIA, MANDREL. ST 5300 CBM-1 J-O-N NOMINAL SIZE 3/8 inch 1-12	MAX DIA MANDREL ST5300 CBM-I J.O.N MANDREL MATERIAL H-H-mitrided MANDREL TAPER: 0.045 inch/inch PULL X PUSH LUBRICATION: Fel Pro 300 (on sleeve) Eleve THICKNESS: 0.3737 inch SLEEVE THICKNESS: 0.3737 inch LID CM COMPOSITION CAL4V STACK UP: 3/8 inch Retained frole Size prior to C.W Finish parior Expansion Top Mid. Bot LiD CM Galc Top Mid. Bot Size prior to C.W Galc LiD CM Galc Top Mid. Bot Galc Top Mid. Bot Galc Gal	MAX_DIA_MANDREL. ST\$300 CBM-()-O-N	MAX DIA MANDREL: ST\$300 CBM-() John MANDREL MATERIAL H1I-mitrided MANDREL TAPER 0.045 inch/inch	MAX DIA MANDREL 0.3537 inch MANDREL MATERIAL H1-nitrided MANDREL TAPER 0.045 inch/inch	MAX DIA MANDREL. 3537 inch MANDREL MATERIAL Hilanitided MANDREL TAPER Q045 inch/inch MANDREL MATERIAL Hilanitided MANDREL TAPER Q045 inch/inch MANDREL DIA + 2 x SLEEVE THICKNESS Q3237 inch Size Prior to CW Cast Tilanium Size after CW Cast Tilanium Size after CW Cast Tilanium Size after CW Cast Tilanium Size after CW Cast Tilanium Size after CW Cast Tilanium Size after CW Cast Tilanium Size after CW Cast Tilanium Size after CW Cast Tilanium Size after CW Cast Tilanium Til	MAX DIA MANDREL ST \$300 CBM + 1-0.N MAX DIA MANDREL TAPER DIAMANDREL TAPER MANDREL TAPER MANDREL TAPER DIAMANDREL TAPER MANDREL TAPER DIAMANDREL TAPER MANDREL TAPER DIAMANDREL TAPER MANDREL TAPER MANDREL TAPER DIAMANDREL TAPER MANDREL DIAMANDREL TAPER MANDREL DIAMANDREL DIAMANDREL DIAMANDREL TAPER MANDREL DIAMANDREL DIAMANDREL TAPER MANDREL TAPER MANDREL DIAMANDREL TAPER MANDREL DIAMANDREL TAPER MANDREL TAPER MANDREL DIAMANDREL TAPER MANDREL DIAMANDREL TAPER MANDREL TAPER MANDREL DIAMANDREL TAPER MANDREL TAPER MANDREL TAPER MANDREL DIAMANDREL TAPER MANDREL MANDREL STATE ST	

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PHASE I-TASK I-MANDREL TAPER DETERMINATION

			اد . اد .)	Bot.	0100	0100	0100	0100					
		ţ	Retained hole expansion (calc.)	Mid.	90075	0075	9/00	0000					
	h/inch	80	Ret expa	Тор	9600	0095	0600	9600					
ì	R: 0.015 inc	1-1/2 inches	Sleeve	thin out	100.	.001	.001	100.					
	MANDREL TAPER: 0.015 inch/inch Fel Pro 300 (on sleeve) SS: 0.3738 inch	STACK UP:	Force required	for Mandrei	8400	7550	6540	0909					
VIII	MANI Fel Pro 3 ESS: 0.373	STA	Upset	of hole	,	-	0.0070	1					
UMBER	L SIZE: 3/8 inct H:II-nitrided LUBRICATION: _ SLEEVE THICKN		Upset	of hole	1	6900	١	1					4 holes
TEST PLATE NUMBER:_	MANDREL MATERIAL: H-II-nitrided MANDREL LUBRICATION: Fel Pro 300 (or	6AI-4V	Finish	after CW	10	į	ì	l					3522 inch ir
TES	MATER	TON.		Bot.	3650	3650	3650	3650					ced to 0.
	NNDREL	COMPOSITION	Size after CW*	Mid	3625	3625	3625	3625		 			vely redu
	1 < 1	5	Size	Тор	3650	3650	3645	3650					progressi
1017	17 5300 CBM-()		Maximum	(calc.)	.0157	.0155	.0153	.0152					Mandrel diameter progressively reduced to 0.3522 inch in 4 holes
TEST NUMBER:	MANDREL: ST 5300 CBM-()-O-N MAX. DIA. MANDREL: 0.3538 inch PULL: X SLEEVE THICKNESS: 0.010 inch	Titanium	Finish prior	to CW	20	1	1	ı					₽W △
Ţ	ANDREI PULL:_	ERIAL.	. <u>«</u>	Bot.	3550	3550	3550	3550					
	C DIA.M	TEST MATERIAL	Size prior to CW*	Mid.	3550	3550	3550	3555	_				005 inch
		TE	Size	Top	3555	3555	3555	3555					To nearest 0.0005 inch
	\triangle		Hole	no.	A2	A3	A4	A5					To ne

PHASE I.. TASK I.. MANDREL TAPER DETERMINATION

							,		 -				 			3
						ان ان ()	Bot.	0100	0105	0105	0100	9600				
						Retained hole expansion (calc.)	Mid.	2000	0800	0080	0000	0000				
		th/inch	,		50	Ret	Тор	9600	0100	0105	9000	5600				
i		R. 0.030 inc	-		1.1/2 inches	Sleeve	thin out	100.	100.	100.	100.	100.				
		MANDREL TAPER: 0.030 inch/inch	Fel Pro 300 (on sleeve)	inch	STACK UP:	Force	for Mandrel	4760	4800	4780	4840	4840				
	(-12)	MAN	Fel Pro 3	ESS:0.373	STA	Upset	of hole	l	l	.0072	١	1				
JMBER	3/8 inch (-12)	nitrided	LUBRICATION: _	E THICKN		Upset	of hole	8900	1	1	1	ı				5 hotes
TEST PLATE NUMBER	NOMINIAL SIZE	MANDREL MATERIAL: H-II-nitrided	LUBRI	MANDREL DIA. + 2 x SLEEVE THICKNESS: 0.3731 inch	6AI-4V	Finish	after CW	ļ	l		l	12				3525 inch (r
TES	NON	MATER		il DIA. 4	FION		Bot.	3650	3650	3650	3650	3645				ced to 0.
		NOREL		VIANDRE	COMPOSITION	Size after CW*	Mid.	3620	3625	3625	3620	3620				ively redu
	A-()-0-N	Ϋ́		1	0	Size	Top	3645	3650	3650	3645	3645				progress
1027	ST 5300 CBM-()-O-N	4	PUSH	SS. 0.010 inch		Maximum	(calc.)	.0162	.0161	.0161	.0156	.0155				Mandrel diameter progressively reduced to 0.3525 inch in 5 holes
TEST NUMBER:	MANDREL	0.3531 inch	×	SLEEVE THICKNESS: 0.010	Titanium	Finish prior	to CW		l	1	1	20				å A
E L	~	ANDREL	PULL	SLEE	ERIAL	. A!	Bot.	3550	3545	3545	3550	3550				
		MAX. DIA. MANDREL.			TEST MATERIAL:	Size prior to CW*	Mid	3545	3545	3545	3550	3550				O5 inch
		MAX			T E	Size	de1	3550	3550	3545	3550	3550				To nearest 0.0005 inch
		Δ				Hole	٥	A6	Α7	88	18	82				To ne

PHASE INTASK INMANDREL TAPER DETERMINATION

The second statement of the second se

			ign. Bart	0010	0110	0010	0190	0110						
		1	Retained noice expansion cele r	0075	0075	. c. 200	0000	0800			:		!	
	ch/inch	20	Retr expa Top	0600	0600	0100	0600	0600	— 		1	• : !	!	
1	R 0.045 inc	1-1/2 inches	Sleeve thin out	100	100	100	100	100			:		!	
	3/8 inch (-12) MAN DREL LAPER 0.045 inch/inch Fel Pro 300 (on sleevel	3737 inch STACK UP	Force required for Mandret	4700	5180	4500	4760	0009			i 	1		
VIII	3/8 inch (12) MAN:():RE Fel Pro 300 (6A14V STACK UESS: 0.3737 inch	Upset exit of hote	1 ;	, !	- 1		0700.	· · · · · · · · · · · · · · · · · · ·	· -·		• - ·	; 	
	L Si7E H-II-nitrided LUBRICATION	E THICKN	Upset entrance of hole	:		00700	* · · 	†	 		 			5 holes
TEST PLATE NUMBER	MANDREL MATERIAL HUnitrided	2 × SLEEV	Finish after CW		· •	&	1	1	!	1	:			el diameter progressively reduced to 0.3533 inch in 5 holes
16.9	MATER	4	y. Bot	3650	3660	3650	3645	3655		 	i I	-		ced to 0
	ANDREL	MANDREL DIA	Size after CW*	3625	3625	3625	3620	3630		!	• : !			vely redu
	W		do I	3640	3640	3650	3640	3640		 	 			progressi
1D3T	15	.SS 0.010 inch	Maximum Pypanskun {calc }	0165	0165	.0164	0163	.0163			:			ndrel diameter
TEST NUMBER	0.3537 inc	SLEEVE THICKNESS	Frash prior to CW	 - 		82	. :	ì						Wandr
16	ANDREL PULL: _	SLEE ERIAL.	NV. Bot	3550	3550	3550	3545	3545						
	MAX DIA.MANDREL. PULL:	SL TëST MATERIAL	Size prior to CW B	3550	3550	3550	3550	3550						05 inch
		T.	Size j Top	3550	3550	3550	3550	3550						Transact 0 0005 meh
	\triangle		Hale	83	84	85	98	87						. T. p. c.m.

PHASE I - TASK I MANDREL TAPER RETERMINATION

							Bot.	0900	9900	0920	0045						
		1				Retained hole expansion (calc.)	Mid.	0035 0	0035 0	0035 0	0025 0		 				
		inch				Retain	Top	0040	0045 0	0020	0045 0	 					
		15 inch/	İ		1.1/2 inches	, e							 		-		
1		E R : 0.0	re)		1.1/2	Sleeve	thin out	.0005	.0005	.000	.0005		 				
		MANDREL TAPER: 0.015 inch/inch	Fel Pro 300 (on sleeve)	38 inch	STACK UP: _	Force	for Mandrel	7320	7520	5540	4220					-	
VIII	3/8 inch (-12)	MAN	Fel Pro	JESS: 0.37	ST,	Upset	of hole	1	.0045	1				 			
UMBER	- 1	nitrided	LUBRICATION	Æ THICKN		Upset	of hole		1	5 E00	1						n 4 holes
TEST PLATE NUMBER	NOMINAL SIZE:	MANDREL MATERIAL H-II-nitrided	- LUBRI	MANDREL DIA. + 2 × SLEEVE THICKNESS. <u>0.3738 in</u> ch	6AI 4V	Finish	after CW	1	ı	10	1						.3523 inch i
TES	NON	MATER		L DIA.	TON.		Bot.	3650	3655	3655	3650						oot paor
		INDREL		MANDRE	COMPOSITION	Size after CW*	Mid	3640	3640	3640	3630						ively red
	CBM-()-0-N	M			ŏ 	Size	Тор	3645	3650	3555	3650						r progress
1E1T	ST 5300 CBM	5	PUSH	SC 0.010 inch		Maximum	(caic.)	.0115	0110	0108	.0108						Mandrel diameter progressively reduced to 0.3523 inch in 4 holes
TEST NUMBER	MANDREL	0.3538 inch	×	SLEEVE THICKNESS:	Titanium	Finish prior	to CW	-	ı	20	1						Ž
11	_	ANDRE	PULL	SLE	ERIAL:		Bot	3605	3605	3605	3605						
		MAX. DIA. MANDREL:			TEST MATERIAL	Size prior to CW*	Mid	3605	3605	3605	3605						O5 inch
		MAX			TE	Sizer	Top	3605	3605	3605	3605						To nearest 0.0005 inch
		Δ				Hole	ē.	5	23	ន	2						To ne

PHASE 1-TASK 1-MANDREL TAPER DETERMINATION

0055 0900 0900 0055 0055 Bot. Retained hole* expansion (rale.) 0035 0030 6040 0035 9035 Mid MANDREL TAPER: 0.030 inch/inch Top 0040 0045 0045 9040 **007**0 1.1/2 inches Sleeve thin out 2000 0005 0005 5000 0005 Fel Pro 300 (on sleeve) Force required for Mandrel STACK UP: 3940 3180 3380 3300 3400 MANDREL DIA. + 2 x SLEEVE THICKNESS: 0.3720 inch of hole Upset exit 0045 3/8 inch (-12) ı 1 ١ ١ **\(\bar{\}\)** Upset entrance of hole LUBRICATION: TEST PLATE NUMBER 0038 MANDREL MATERIAL: H-11-nitrided ١ t 1 NOMINAL SIZE: 6AI-4V Finish after CW 1 1 ŧ 5 3660 3660 3660 3665 3660 Bot. COMPOSITION: Size after CW* 3640 3640 3640 3635 3640 Mid ST 5300 CBM-()-O-N Top 3645 3645 3650 3645 3650 SLEEVE THICKNESS: 0.010 inch PUSH expansion (calc.) Maximum .0105 .0105 .0105 1E2T .0105 .0105 TEST NUMBER: MAX. DIA. MANDREL 0.3520 inch MANDREL Finish prior to CW Titanium ₩ ŧ ı TEST MATERIAL: 3600 3605 3605 3605 3605 Bot. Size prior to CW* To nearest 0.0005 inch 3605 3605 3605 3605 860 Mid Top 3605 3605 3605 3605 3605 Hote 22 ဗ ප 5 \mathcal{C}

PHASE I. LASK I. MANDREL TAPER DETERMITATIOM

TEST NUMBER VIII	MANDREL: ST 5300 CBM-().O.N NOMINAL SIZE 3/8 inch (-12)	MAX. DIA. MANDREL 0.3539 inch MANDREL MATERIAL H-II-nitrided MANDREL TAPER: 0.045 inch/inch	PULL: X PUSH: LUBRICATION: Fet Pro 300 (on sleeve)	SLEEVE THICKNESS: 0,010 inch MANDREL DIA. + 2 × SLEEVE THICKNESS:0,3739 inch	TEST MATERIAL: Titanium COMPOSITION: 6AL4V STACI UP: 1-1/2 inches	
		MAX DIA.			TEST MA	بمصفحسين
						1

ie •	Bot.	0055	0055	9000	0900	90055	0055		
Retained hole expansion (calc.)	Mid.	0040	0035	0500	0040	0040	0040		
Ret	Тор	5500	0020	0045	0045	0045	0045		
Sieeve	thin out	5000	5000	.0005	50005	5000	5000		
Force	for Mandrel	3280	2760	3060	3120	2920	3450		
Upset	of hc!e	-	1	l	.0045	1	ł		
Unset	of hole	ļ	.0038	ı	l	ł	ŀ		
Finish	after CW	1	1		∞	1	1		_
	Bot.	3660	3660	3665	3665	3660	3660		
Size after CW*	Mid	3645	3640	3640	3640	3640	3640		
Size	Тор	3660	3665	3650	3650	3650	3650		
Maximum	(calc.)	9110.	.0119	.0119	.0117	.0114	.0122		
Finish prior	to CW	j		} 	15	ı			
, »	Bot.	3605	3605	3600	3605	3605	3605		
Size prior to CW*	Mid	3605	3605	3600	3605	3605	3605		
Size	Top	3605	3605	3605	3605	3605	3605		
Hole	ė	53	04	05	90	07	80		
_								 	

PHASE LITASK LIMANIDREL TAPER DETERMINATION

			–	TEST NUMBER	1F1T			TES	TEST PLATE NUMBFR	UMBF R	VIII		1			
				MANDREL _	ST 5300 CBM-()-O-N	NO()	1	CN	NOMINAL SIZE	3/8 inch (-12)	h (-12)					
	MAX	OIA N	MAX DIA MANDREI	1 0.3523 inch	f)	Š	MANDREL MATEPIAL	MATEP		H-II-nitrided	MAN	MANDREL TAPER 0.015 inch/inch	9 0015 In	ch/inch		
			PULL .	×	PUSH				LUBRI	LUBRICATION -	- 1	Fel Pro 300 (on sleeve)		1		
			SI.E	SLEEVE THICKNESS	SS 0.010 inch	İ	MANORE	EL DIA	MANDREL DIA + 2 x SLEEVE THICKNESS. 0.3723 inch	/E THICKN	FSS 0.372	3 inch				
	TE	TEST MATERIAL	ERIAL .	Titanium		J	COMPOS, TION	TION _	6A!-4V		\$17	STACK UP	1-1/2 inches	16	i	
ž Č	2715	Size prior to CW*	CW.	Finish prior	Maximum	Sis	Size after CW*	,	Finish	Upset	Upset	Fon e	araa15	Ret	Retained hole expansion (calc.)	اَي وَ
9	Top	Mich	Bot	10 CW	(calc.)	Top	Mad	Bot.	after CW	of hole	of hote	for Mandret	thin cot	lop	Mid	Вол
E1	3555	3655	3655	1	8900	3660	3660	3665	1		1	5340	None	9000	5000	00
E2	3692	3655	3660	18	8900	3660	3650	3670	10	.0024	.0032	4260	None	9000	9009	010
E3	3655	3655	3655	ţ	8900	3660	3660	3670	١	1		4800	None	9000	9000	315
+ 4	3660	3655	3655		8900	3675	3660	3675	1] : :	 	3500	None	0015	9000	2200
53	3655	3655	3655	,	8900	3670	3665	3675		•	1	3400	None	0015	0010	00500
	!		! i	:						i i	: :	!				1
							 		:	: : :		:				
						!										
												1	:		j	
1	To nearest 0 0005 unth	305 unch														

PHASE I TASK I MANDREL TAPER DETERMINATION

1527 TEST PLATE MUNBER VIII	34 (12) ST 5300 CBM (1-0-N NOMINAL SIZE 3/8 inch (-12)	MANDREL TAPER: 0.3520 inch WANDREL MATERIAL H-H-nitrided MANDREL TAPER: 0.030 inch/inch	PULL X PUSH: LUBRICATION Fel Pro 300 (on sleeve)	Skeeve thickness <u></u>	TEST MATERIAL Transmiss COMPOSITION 6AI-4V STACK UP: 1-1/2 inches
<u>.</u>		MAN DIA MANDRES	- 1. J. J. C	.e.; 15	TEST MATERIAL

e' Ic.)	Bot.	0030	0030	0035	0015	0015				
Retained nole * expansion (calc.)	Mid.	0015	0000	0015	0010	0010				
Ret	Тор	0020	0025	0025	0010	0100				
Sleeve	thin out	None	None	None	None	None				
Force required	for Mandrel	1630	1600	1495	1925	1910				
Upset	of hole	1	1	.0030	1		· = • · · · · · · · · · · · · · · · · ·			
Upset	of hole		.0025		1	ı				
Fınish	after CW	١	1	8	1	l				
	Bot.	3685	3685	3685	3670	3670				
Size after CW*	Mid.	3670	3675	3570	3665	3665			i	
Size	Top	3680	3680	3680	3665	3665				
Maximum	(calc.)	5900'	900	.0065	.0065	.0065				
Finish prior	NO E	ı		15	1		· · · — · · · · · · · · · · · · · · ·	~~-	 	
1.8	Bot	3655	3655	3650	3855	3655				-
Size prior to CW.	Mid	3655	3655	3655	3655	3655				
Sizes	Top	3660	3655	3655	3655	3655				
HOte	5	E6	E7	E8	Ē	F2				

PHASE I-TASK FINANDREL TAPER DETERMINATION

THE METERS OF THE TWO IS NOT THE PROPERTY OF T

					ر م اد اد	Ť.	 	. g .	' 'S	8	
				i	Retained hole	P211.	0015	001	0020	0020	
	:	ch/inch		81	eux Väg	- I	0020 0015	0050	9200	0025	
	•	R: 0.045 inc		1.1'2 inches	Sleme	thus wit	None	None	None	None	
		Fer Prot 100 considered	7 inch	STACK UP:	paur but	tar Mondrel	2000	2220	2040	2000	
. Val	h (-12)	* 3 d 3 d 3 d 3 d 3 d 3 d 3 d 3 d 3 d 3	MANDREL DIA + 2 x SLEEVE THICKNESS 0.3737 inch	STA	Upset	of note			!	!	
. Starter	NOMINAL SIZE 3/8 inch (-12)	Z	/E THICKN		Upset	of hole	1	1	;	,	-
TEST PLATE NUMBER	MINAL SIZE	MANDREL MATERIAL H.II.nitrided	2 × SLEE	6AI-4V	Finish	ofter CW	i	i	12		
765	NON	MATER	EL DIA	NOI	. >	Bot	3685	3685	3690	3690	!
		ANDREL	MANDRI	COMPOSITION	Size after CW*	Mrd	3670	3670	3675	3675	
	N-O-()-N			3	135	Top	3675	3675	3680	3680	
1F3T	ST 5300 CBM-()-0-N	PUSH	.SS: 0,010 inch		Maximum	(calc.)	0082	.0082	.0082	.0082	
TEST NUMBER	MANDREL	0.3537 inch X	SLEEVE THICKNESS:	Titanium	Fusish prior	to CW	1	1	80		
#	_	ANDRE!	SLE	ERIAL:_	. M.	Bot	3655	3655	3655	3655	
		MAX DIA MANDREL		TEST MATERIAL:	Size prior to CW	Mrd.	3655	3655	3655	3655	_
		MA		11	Size	Тор	3655	3655	3655	3655	
					_22	•			İ	!	

Hols Size puict to CW Figure, prior extranson 150 Mad 8nd Affect Williams 1 10 Mad 8nd Affect Williams 1 10 Mad 8nd Affect Williams 1 10 Mad 8nd Affect Williams 1 10 Mad 8nd Affect Williams 1 10 Mad 8nd Affect Williams 1 10 Mad 8nd Affect Williams 1 10 Mad 8nd Affect Williams 1 10 Mad 9nd 1 10 Mad 9nd Williams 1 10 Mad 9nd 1 10 Mad 9nd 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10 Mad 9nd 1 10	Returned hate	Tage The Best.	0020 0015 0030	0020 0015 003C	0025 0020 0035	0025 0020 0035	0025 0015 0035					
Top Mrd. Bot CV Firsth prior Pharmium Syze after CV Finnsh Unser Upper	Sleme										 	
Top Mird Bort Ernsch prior Finish Ernsch Er	palicolor (tar Sandrel	2000	2220	2040	2000	2040					
Size prior to CW Fineth prior Maximum Size after CW Finish	Upset	of note	-		!		0035					
Size prior to CW Friesh prior Maximum Size after CM Top Mid Bot to CW to CW to CW 3655 3655 3655 -	Upset	of hole	i	- 1	1	<u> </u> 	.0025	! !	 			
Size prior to CW Finesh prior Maximum Size affer CW Top Mrd Bor to CW Expansion Top Mrd 3655 3655 3655 -	Finish	after CW	ì	, , , ,	12		 	: : !		1	!	
Size prior to CW Fresch prior Maximum Top Mid. Bot to CW (calc.) Top Mid. Bot to CW (calc.) Top Mid. Bot to CW (calc.) Top Mid. Bot Top Mid. Bot Top Mid. Bot Top To	. >	Bot	3685	3685	3690	3690	0698	!	 	:	 	
Size prior to CW Fresch prior Maximum Top Mid. Bot to CW (calc.) Top Mid. Bot to CW (calc.) Top Mid. Bot to CW (calc.) Top Mid. Bot Top Mid. Bot Top Mid. Bot Top To	a after Cy	Mid	3670	3670	3675	3675	3670	:		i		
1c Size prior to CW Fursh prior to CW Top Mid. Bot to CW To	iş.	Top	3675	3675	3680	3680	3650			:	! !	
1c Size prior to CW Top Mrd. 801 3655 3655 3655 3655 3655 3655 3655 3655	Maximum	(calc.)	.0082	0082	.0082		.0082	: :				
3655 3655 3655 3655 3655 3655 3655 3655	Firsth prior	to CW	1	i : 	20	: : 1	1			1		·
36 36 36 36		Bot	3655	3655	3655	3655	3655					
38 98 98	, ,×	[ડડ	929	3655			 		-
Hote F5 F5 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7 F7	prior to CW		3655	365	36	. n	<u>i </u>	i		<u>i</u> -	<u> </u>	
	Size prior to CW	Mid	├	 -			 					

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PHASE I-TASK I MANDREL TAPER DETERMINATION

PHASE LUTASKU MAGOR UTAPER DURANDELING

				1 5000 1 0 1	9. C						: 	 		Ì
	1:0:	ı	Retiried tole	0, 0	0316	<u></u>		: :	:	! ··· -	-	!	:	<u>.</u>
	6.030 inchracon		Ret ext. Top	0190	012.				}			!	!	İ
		2 inch	Sleeve thin out	100.	000									
	Hilmitrided Manji-REL LAPER LUBRICATION FELP C 300 ton slewel	3.7458 :nch STACK UP:	Force required 100	16 200) () () () () () ()		i i i	; 	! : :			, ; ;	i :	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
¥.	3.4 inch (24) led Mary DN: Fe! Pic 3	MANDREL DIA. + 2 × SLEEVE THICKNESS. 0.7458 inchicomposition 6AI-4V	Upset exit of hole	3110	1	· · · · ·			!	: :		:	:	
JUSHBER .	L 51ZE3.4 Hill-nitrided LUBRICATION	VE THICKN	Upset entrease	08:00	1	į	•		. ,	• • •	:	•••		10.00000
FST PLATE UDSBER	-1 .	- 2 x SLEE	Finish after CW	;	ie	-	· ·							
	3.63 MATER	EL DIA.	Egg.	7340	Q.	(uni s < 10 (suit.)) = =
	MANDREL MATERIAL	MANDREL DIV	Size after City	731d	7300			1	• -		: :	:		167
<u>L</u>	20 E		Size	73.80	2.0				1	. ~ · ! !	!	 	· · · · · · · · · · · · · · · · · · ·	!
1621	ST 5300 CBM-(SS: 0.015 inch	Płąwinium Pspatiskin (cale)	8520.	0297				:			!		
TEST MUNIER	10 JOHEL ST 5300	SLEEVE THICKNESS: 0.01 AL Titanium	Fusici prior to CW		ဗွ			 			;		, 	
LU L	ANDREL PULL	SLEE	Sot	7145	7145		! !			:		<u> </u>		1
	NAX DIALEMANDREL	SL TEST MATERIAL	Size and to CW	7140	7145	†	! ·							
	WAX)- -	Sizer	7:40	714C			!		·	!			12 362 es 3 0000 mon
	\triangle		Hotel	83	84				!					

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PHASE I-TASK I-MANDREI, TAPER DETERMINATION

		th/inch	ı			Returned hole
1		R 0.045 inc	(a)		2 inch	
		MANDREL TAPER 0.045 inch/inch	Fel Pro 300 (on sleeve)	448 inch	STACK UP:	Force
×	3/4 inch (-12)	MAN		NESS: 0.7	STA	
TEST PLATE NUMBER	,	1-nitrided	LUBRICATION: _	EVE THICK		-
EST PLATE	NOMINAL SIZE	RIAL HI	רתפ	. + 2 × SLE	6AI-4V	
T		MANDREL MATERIAL H.II-nitrided		MANDREL DIA. + 2 x SLEEVE THICKNESS: 0.7448 inch	COMPOSITION	
1G3T	ST 5300 CBM-()-O-N		PUSH	SLEEVE THICKNESS: 0.015 inch		-
B.F.R	ST 53	48 inch		CKNESS	Titanium	-
TEST NUMBER	MANDREL	Et. 0.71	×	EEVE THI	Ĭ	
		MAX DIA MANDREL 0.7148 inch	- אחור	SL	TEST MATERIAL	
		Δ				-

	Size 1	Size prior to CW	C'W.	Finish prior	Maximum	Size	Size after CW*	٠.	Finish	Upset	Upset	Force	Sleeve	Ret	Retained hole expansion (calc.)	e .
	Top	Mid	Bot	to CW	(calc.)	Top	Mid	Bot.	after CW	of hole	of hole	for Mandrel	thin out	Too	Mid	Bot.
1	7140	7140	1740	I	.0288	7295	7275	7335	1	l	1	14,500	100.	0155	0135	0195
1	7140	7140	7140	 	.0283	7295	7275	7335	i		l	12,600	100	0155	0135	0195
j.	7140	7140	7140	 	0282	7299	7275	7335	I	.0065	0600	14,100	.001	0155	0135	0195
)	7140	7140	7140	40	.0282	7298	7275	7338	18	ı	l	14,000	.001	0155	0135	0195
	7140	7140	7140	١	.0280	7295	7279	7339	1	-	1	13,600	100.	0155	0135	0195
1																
i																
1																
1																
5																
1 🛱	To nearest 0.0005 inch	05 inch					₽	Mandrel	diameter pr	ogressively	reduced to (Mandrel diameter progressively reduced to 0.7140 inch in 5 holes	o 5 holes			

Mandrel diameter progressively reduced to 0.7140 inch in 5 holes.

PHASE I. TASK I-MANDREL TAPER DETERMINATION

The second secon

				Bot.	0140	0140	0140	0140	0135]
	1		Retained hole* expansion (calc.)		0115	0120	0115 (0115 (0115 (
	£		Retained hole xpansion (calc.	Mid.							 -		
	inch/inc		a s	Тор	0150	0155	1045	0150	0150				
}	R 0.020	2 inch	Sleeve	thin out	100.	100.	.00	.001	100:				
	MANDREL TAPER: 0.020 inch/inch Fel Pro 300 (on sleeve)	STACK UP:	Force	for Mandrel	15,500	16,500	16,800	15,400	16,700			-	
×	3/4 inch (-24) ed MAN ION: Fel Pro HICKNESS: 0.7	51.	Upset	of hole	1	1	.0085	1	l				
UMBER _	L SIZE: 3/4 im H-II-nitrided LUBRICATION: _		Upset	of hole	-	1	.0025	l	1				
TEST PLATE NUMBER	MANDREL MATERIAL H-II-nitrided MANDREL TUBRICATION: Fel Pro 300 (on MANDREL DIA, + 2 × SLEEVE THICKNESS: 0.7458 inch	6AI-4V	Finish	after CW	1	25	ł	ı	l				
TES.	MATERI MATERI	JON:		Bot	7335	7335	7335	7335	7330				
	NNDREL	COMPOSITION	Size after CW*	Mid.	7310	7315	7310	7310	7310			 	1
	()-0-h	5	Size	Тор	7345	7350	7340	7345	7345				
1H1T	5300		Maximum	(calc.)	.0243	.0243	.0243	.0243	.0243				
TEST NUMBER	MANDREL: ST DREL 0.7158 inch L: X SLEEVE THICKNESS	Titanium	Finish prior	to CW	į.	909		t	ŀ				
F	MAX DIA. MANDREL PULL:	ERIAL		Bot.	7198	7195	7195	7195	7195				
	DIA. M	TEST MATERIAL	Size prior to CW*	Mid	7195	7195	7195	7195	7195				5 inch
	A X X	TES	Sizep	Top	7195	7195	7195	7195	7195				To nearest 0.0005 inch
			Hole	ō.	ΙĄ	A2	A3	A4	181				To nea

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PHASE I-TASK I.-MANDREL TAPER DETERMINATION

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					٠. و	Bot.	0155							
				1	Retained hole* expansion (calc.)	Mid.	0120			-		-		ĺ
	0,030 inch/inch				Ret	Тор	0135							
i				2 inch	Sleeve	thin out	0100.							
		Fel Pro 300 (on sleeve)	58 inch	STACK UP:	Force	for Mandrei	13,250							
×		ايق	ESS: 0.73	S17	Upset	of hole	.0130							
UMBER	3/4 inch (UBBICATION	E THICKN		Upset	of hole	.0045							
TEST PLATE NUMBER	NOMINAL SIZE: 3/4 inch (-24)	MANDREL MATERIAL:	MANDREL DIA. + 2 x SLEEVE THICKNESS: 0.7358 inch	6AI-4V	Finish	after CW	15							
TES	NON	MATER	L DIA.	LION: I		Bot.	7350							
		NDREL	AANDRE	COMPOSITION	Size after CW*	Mid	7315							
	N-O-(ļ	ا ۽	ğ	Size	Тор	7330	j						
1H2T	T 5300 CBM-(HSIId	0.015		Maximum	(calc.)	.0243							
TEST NUMBER:	MANDREL: ST 5300 CBM:()-O-N		SLEEVE THICKNESS:	Titanium	Finish prior	to CW	58							
11	_	MAX. DIA. MANDREL:	SLE	TEST MATERIAL:_	, MC	Bot.	7195							
		: DIA: M		ST MAT	Size prior to CW	Mid	7195							M. John
		₹ X		TE	Size	Top	7195							420. 3000 C 12220 CT.
					Hofe	OL.	2							100

PHASE 1 - TASK 1-MANDREL TAPER DETERMINATION

TEST PLATE NUMBER

1H3T

TEST NUMBER

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MANDREL TAPER: 0.045 inch/inch Pro 300 (on sleeve) 0.7454 inch	2 inch	ed Sieeve expansion (calc.)	thin out Top Mid. Bot.	0135 0105 0145	0 .001 0125 0095 0145	0 .001 0130 0090 0145	0 .001 0125 0095 0145	0 .001 0125 0095 0145				
Fel Pro 300 (on sleeve)		Upset Force required	of hole Nandrel	12,500	12,000	12,200	.015 12,900	11,600				
LUBRICATION:	MANUTEL UIA. + ZX SLEEVE PHICKNESS: OMPOSITION: 6AI-4V	Upset		-	1	1	0900	1				
	+ 2 x SLEEV 6AI-4V	Finish	after CW	1	1		15	1				
4	TION:	٧.	Bot	7340	7340	7340	7340	7340				
	COMPOSITION:	Size after CW*	Mid.	7300	7290	7285	7290	7290				1
- F	,	Siz	Тор	7330	7320	7325	7320	7320				
PUSH:		Maximum	(calc)	5220	.0238	.0237	.0236	.0236				
CLEVE THICKNESS 0.	Titanium	Fransh prior	to CW	l	1	1	25	j				
PULL:	ERIAL	,MC	Bot.	7195	7195	7195	7195	2195				
	JE TEST MATERIAL	Size prior to CW	Mid.	7195	7195	7195	7195	7195				36.55
	16	Size	Тор	7195	7195	7195	7195	7195				To payred 0 0005
		Hole	00	ឌ	3	ة	02	D3				

PHASE 1-TASK 1-MANDREL TAPER DETERMINATION

					. i c	Bot.	9692	90095	9600	9000	0105			
	ļ				Retained hole expansion (calc.)	Mid.	0000	0/00	0000	0000	0000			
	nch/inch				Ret	Тор	0600	9085	0800	0800	0800			
1	R: 0.020 ir			2 inch	Sleeve	thin out	100	100.	100.	100.	100			
×	MANDREL TAPER: 0.020 inch/inch	Fel Pro 300 (os sleeve)	74 inch	STACK UP:	Force	for Mandrel	15,700	11,800	15,300	15,600	11,900			
	- 1	Fel Pro 3	ESS: 0.74(STA	Upset	of hole	_	.0125	-	1	-			
UMBER	3/4 inch (LUBRICATION: _	/E THICKN		Upset	of hole	_	.0035	l	1	1			
TEST PLATE NUMBER:	O-N NOMINAL SIZE: 3/4 inch (:24) MANDREL MATERIAL: H-II-nitrided	LUBRI	MANDREL DIA. +2 x SLEEVE THICKNESS: 0.7464 inch	SAI-4V	Finish	after CW	-	1	l !	1	20			
TES	NOW		EL DIA.	TION	.>	Bot.	7345	7345	7345	7345	7355			
	ANDREL		MANDRI	COMPOSITION	Size after CW*	Mid	7320	7320	7320	0320	7320			
	~ ·		١	3	Šiš	Top	7340	7335	7330	7330	7330			
T1C1	ST 5300 CBM-(PUSH			Maximum	expansion (calc.)	.0194	.0188	.0188	.0188	.0188			
TEST NUMBER	MANDREL S	*	SLEEVE THICKNESS:	Titanium	Finish prior	to CW	1	 			45			
118	ANDREL	PULL	SLE	ERIAL	·M	Bot	7250	7250	7245	7250	7250			
	MA MAX. DIA. MANDREL:_			TEST MATERIAL	Size prior to CW*	Mid	7250	7250	7245	7250	7245			
				TE	Size	Тор	7250	7250	7250	7250	7250			
	A				aoH	9	FA .	A2	A3	AA	81			

Mandrel diameter reduced to .7158 inch in first hole.

To nearest 0.0005 inch

2

PHASE I TASK I MANDREL TAPER DETERMINATION

					(c.)	But.	9600							
				•	Retained hole expansion (catc.)	Mid.	0900							
	0.030 inch/inch				Ret	ťοb	9200							
ı	1	6		2 inch	Sleeve	thin out	100.							
	MANDREL TAPER	Fel Pro 300 (on sleeve)	98 inch	STACK UP	Force	for Mandret	10,500							
×	h (-24) MAN(MANDREL DIA. + 2 x SLEEVE THICKNESS: 0.7458 inch	STA	Upset	of hole	.0130					 		
UMBER	3/4 inch (-24)	LUBRICATION	/E THICKN		tasdU	of hole	8600.							
TEST PLATE NUMBER:	O-N NOMINAL SIZE 3/4 MANDREL MATERIAL: H-II-nitrided	LUBR	+ 2 × SLEEV	6AI.4V	Finish	after CVV	13							
TES	NOW MATER		EL DIA.	TION:	.>	Bot.	7340							
	ANDREL		MANDRI	COMPOSITION:	Size after CW*	Mid.	7310							
	<u> </u>		ı	3	Sizi	Τορ	7320							
1321	ST 5300 CBM-(PUSH	SS 0.015 inch		Maximum	(calc.)	.0188							
TEST NUMBER	MANDREL S	×	SLEEVE THICKNESS	Titanium	Finish prior	to CW	25	:	:					
TE	1 ANDREL	PULL	SLEI	ERIAL	i.g	Bot	7245							
	M MAX. DIA. MANDREL.			TEST MATERIAL:	Size prior to CW*	Mid.	7250							
	MAX			TE	Size	Тор	7245							
					Hole	S.	23							

To nearest 0 0005 inch

PHASE 1-TASK 1-MANDREL TAPER DETERMINATION

						e • Ic.)	Bot.	9600	0010	0105	0105	0100			
					1	Retained hole expansion (calc.)	Mid.	900	0065	0075	0065	900			
		0.045 inch/inch	1			Ret	Тор	0085	9085	9008	0085	0085			
1		- 1			2 inch	Sleeve	thin out	100.	100.	100	100.	100.			
		MANDREL TAPER:	Fel Pro 300 (on sleeve)	0.7462 inch	STACK UP:	Force required	for Mandrel	8300	8500	9800	8200	8700			-
×	ń.	MAN	Fel Pro 3		STA	Upset	of hole	1	.0135	-	l	1	:		
IUMBER	3/4 inch	H-II-nitrided	LUBRICATION	MANDREL DIA. + 2 × SLEEVE THICKNESS: _		Upset	of hole	l	.0035	l	1	1			
TEST PLATE NUMBER	NOMINAL SIZE	- 1	LUBR	+2×SLEE	6AI-4V	Finish	after CW	l	l	18	1	l			
TES	ON	MANDREL MATERIAL		EL DIA.	TION:	. ~	Bot.	7345	7345	7355	7355	/345			
	7	ANDREL		MANDR	COMPOSITION	Size after CW*	Mid.	7315	7315	7320	7315	7315			
1337	N-0-()-P	2		inch		\\ \text{S}	τορ	7355	7335	7335	7335	7335			
	ST 5300 CBM-(£	PUSH	SS: 0.015 inch		Maximum	(calc.)	.0192	.0184	.0183	.0182	.0185			
TEST NUMBER	MANDREL	0.7162 inch	×	SLEEVE THICKNESS:	Titanium	Finish prior	to CW	-	ı	30	1	l			
1	•	ANDREL	PULL:	SLEI	ERIAL	. M.	Bot.	7250	7245	7245	7245	7245			
		MAX. DIA. MANDREL.			TEST MATERIAL:_	Size prior to CW*	Mid.	7250	7250	7245	7245	7245			
					TE	Size	Тор	7250	7250	7250	7245	7250			
						Hole	no.	C4	10	02	r)3	D4			

A STATE OF THE PARTY OF THE PAR

Mandrel diameter progressively reduced to .7150 inch in 5 holes.

To nearest 0.0005 inch

PHASE I-TASK I-MANDREL TAPER DETERMINATION

TEST NUMBER: 1A1S		TEST PLATE NUMBER: XII	XII
MANDREL: Push (Design per BAC 5972)	BAC 5972)	NOMINAL SIZE	3/8 inch
MAX. DIA. MANDREL: 0.3580 inch	580 inch	MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.015 inch/inch	15 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP	Steel (280/300 ksi)	STACK UP:	3/8 inch

<u></u>									
le alc.)	Bot.	0075	0800	0600	0085	5800			
Retained hole expansion (calc.)	Mid.	00700	0075	0075	0080	0070			
Ret	Тор	0800	0800	0085	9800	0075			
Sleeve	thin out								
Force	for Mandrel	7060	4100	4200	3650	3520			
Upset	of hole								
Upset	of hole								
Finish	after CW	l	l	1	1	25			
	Bot	3530	3535	3535	3535	3535			
Size after CW*	Mid	3520	3520	3515	3520	3520			
Size	đơ:	3525	3525	3525	3525	3525			
Maximum	(cafe.)	0:30	.0135	.0140	.0140	0130			
Finish prior	to CW	1	١	l		26			
	Bot	3455	3450	3445	3440	3450			
Size prior to CW*	Mid.	3450	3445	3440	3440	3450			
Size	Lop	3445	3445	3440	3440	3450			
Hole	<u>6</u>	Æ	A2	A3	A 4	A5			

PHASE I. TASK I MANDREL TAPER DETERMINATION

TEST NUMBER: 1A2S	1A2S	TEST PLATE NUMBER: XII	XII
MANDREL: Push (Design per BAC 5972)	ssign per BAC 5972)	NOMINAL SIZE:	3/8 inch
MAX. DIA. MANDREL:	L: 0.3580 inch	MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.030 inch/inch	0.030 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL:	TEST MATERIAL: 300 'M' Steef (280/300 ksi) STACK UP:	STACK UP:	3/8 inch

····							 	 	
le lc.)	Bot.	0085	0600	9085	9800	0800			
Retained hole expansion (calc.)	Mid.	0070	0075	90065	00700	0900			
Rei expa	Тор	0075	0800	0000	0800	20075			
Sleeve	לואט הורוז								
Force	for Mandrel	6040	4880	4550	4760	4920			
Upset	of hole								
Upset	of hole								
Finish	after CW	l I	1	20	1 1	ı			
۰.	Bot.	3535	3535	3535	3535	3535			
Size after CW	Mid	3520	3520	3515	3520	3515			
Sızı	Тор	3525	3525	3520	3525	3520			
Maximum	(calc.)	.0130	.0135	.0130	.0130	.0125			
Finish prior	to CW	-	1	90	í	ſ			
`W.	Bot.	3450	3445	3450	3455	3455			
Size prior to CW*	Mrct	3450	3445	3450	3450	3455			
Size	Top	3450	3445	3450	3445	3445			
Hole	ė.	A6	Α7	A8	81	82			

PHASE 1-TASK 1-MANDREL TAPER DETERMINATION

TEST NUMBER:	1A35	TEST PLATE NUMBER: XII	X
MANDREL Push (Design per BAC 5972)	esign per BAC 5972)	NOMINAL SIZE	3/8 inch
MAX, DIA, MANDREL:	0.3580 inch	MANDREL MATERIAL:	Carboloy 883 (GE)
MANDREL TAPER: 0.045 inch/inch	0.045 inch/inch	LUBRICATION	Fel Pro 300
FEST MATERIAL:	TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP:	STACK UP:	3/8 inch

	,			——·				 			1
le ' Ic.)	Bot.	0800	0800	0800	0800	0800					
Retained hole expansion (calc.)	Mrd.	900	900	0020	900	0000					
Reta	Top	080	0800	0800	3/00	0800					
Sleeve	thin out								,		
Force	for Mandrel	4860	4280	4860	4940	4820					
Upset	of hole										
Uoset	of hole									_	
Finish	after CW	: 1 [!	1	1	29	-		 		
	Bot.	3535	3535	3535	3535	3535		_			
Size after CW*	Mid	3520	3520	3520	3520	3520					
Size	Top	3525	3525	3525	3525	3525		-			
Maximum	(calc.)	.0125	0130	.0130	.0125	.0130					
Finish prior	to CW	1	 	l	1	S					
, M	Bot	3455	3455	3455	3455	3455					
Size prior to CW	Ard.	3445	3455	3450	3455	3450					15 inch
Size	Top	3445	3445	3445	3450	3445					To pearest 0 0005 inch
Hole	o C	B3	B4	85	98	97					Tones

,也是一个人,也是一个人,我们们是一个人,我们们也是一个人,我们们们们们们们们们们的一个人,也是一个人,也是一个人的人,也是一个人的人,也是一个人的人,也是一个

PHASE I. TASK I. MANDREL TAPER DETERMINATION

XII	3/8 inch	Carboloy 883 (GE)	Fel Pro 300	3/8 inch
TEST PLATE NUMBER:	NOMINAL SIZE:	MANDREL MATERIAL	LUBRICATION:	STACK UP:
1815	ign per BAC 5972)	0.3580 inch	15 inch/inch	'M' Steel (280/300 ksi)
TEST NUMBER:	MANDREL. Push (Design per BAC 5972)	MAX. DIA. MANDREL.	MANDREL TAPER: 0.015 inch/inch	TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP.

Retained hole expansion (calc.)	Top Mid. Bot	0115 0110 0130	0120 0115 0125	0120 0115 0130	0120 0115 0130	0120 0115 0130				
Steeve thin out										
corce required	for Mandrel	5260	9200	5500	5880	7360				
Upset	of hole					;				
Upset entrance of hole										
Finish	after CW	;	ı	35	J	1			 	
• (Bot.	3525	3520	3525	3525	3525				
Size after CW*	Mid.	3505	3510	3510	3510	3510				
Size	Тор	3510	3515	3515	3515	3515	i i			
Maximum	(calc.)	.0185	.0185	.0185	.0185	.0185				
Finish prior	to CW		, !	08		1				
.M.	Bot	3395	3395	3395	3395	3395				
Size prior to CW*	Mid.	3395	3395	3395	3395	3395				
Size	Тор	3395	3395	3395	3395	3395				
Hole	ō.	ت	23	ප	ষ	ઈ				

PHASE I. TASK I-MANDREL TAPER DETERMINATION

	nch	Carboloy 883 (GE)	Fel Pro 300	nch
×	3/8 inch	Carb	FelF	3/8 inch
TEST PLATE NUMBER: XII	NOMINAL SIZE:	MANDREL MATERIAL:	LUBRICATION	STACK UP
1825	Design per BAC 5972)	0.3580 inch	0.030 inch/inch	300 'M' Steel (280/300 ksi) STACK UP
TEST NUMBER: 182S	MANDREL Push (Design per BAC 5972)	MAX, DIA MANDREL.	MANDREL TAPER 0.030 inch/inch	TEST MATERIAL:

Retained hole expansion (calc.)	Mid. Bot.	0115 0130	0115 0130	0115 0130	0115 0130	0115 0130					
Reta expan	Тор	0120	0120	0120	0120	0120					
Sleeve	thin out										
Force	for Mandrel	7000	6420	0009	5780	7480		ì			
Upset	of hole										
Upset	of hale										
Finsh	after CW	1	32	i :	1	1				i i	
	Bot	3525	3525	3525	3525	3525					İ
Size after CW*	Mid.	3510	3510	3510	3510	3510	- 			!	
Size	Тор	3515	3315	3515	3515	3515			:	!	
Maximum	(calc.)	.0185	0.185	.0185	0185	.0185	! : :				
Finish prior	to CW	!	08	1	;						
. ANC	Bot	3395	3395	3395	3395	3395					
Size prior to CW*	Mid	3395	3395	3395	3395	3395	 		:		
Size	Top	3395	3395	3395	3395	3395					
Hole	οu	90 90	7.2	8	10	02	: : : :				

PHASE I. TASK I-MANDREL TAPER DETERMINATION

1			Ì	
×	3/8 inch	Carboloy 883 (GE)	Fel Pro 300	3/8 inch
TEST PLATE NUMBER: XII	NOMINAL SIZE:	MANDREL MATERIAL: Carboloy 883 (GE)	LUBRICATION:	STACK UP:
1835	MANDREL: Push (Design per BAC 5972)	L: 0.3580 inch	0.045 inch/inch	TEST MATERIAL: 300 'M' Steel (280/300 ksi)
TEST NUMBER: 183S	MANDREL: Push (MAX. DIA. MANDREL:	MANDREL TAPER: 0.045 inch/inch	TEST MATERIAL:

Hole	Size	Size prior to CW	.mc	Finish prior	Maximum	Sızı	Size after CW*	٧.	Finish	Upset	Upset	Force	Sieeve	Rei expa	Retained hole expansion (calc.)	le" Ic.)
OL	Тар	Mid	Bot	to CW	(calc.)	Тор	Mid.	Bot.	after CW	of hote	of hole	for Mandrel	thin out	Тор	Mid.	Bot.
D3	3395	3395	3395	1	.0185	3515	3510	3525	-			5980		0120	0115	0130
D4	3395	3395	3395	1	.0185	3515	3510	3525	1			6040		0120	0115	0130
05	3395	3395	3395	8	.0185	3515	3510	3525	30			7660		0120	0115	0130
90	3395	3395	3395	١	3810.	3515	3510	3525	-			0069		0120	0115	0130
07	3395	3395	3395	ı	.0185	3515	3510	3525	t			5880		0120	0115	0130
	10000	40.5														

PHASE 1-TASK 1-MANDREL TAPER DETERMINATION

TEST NUMBER 1CIS	1015	TEST PLATE NUMBER:	IIX
MANDREL: Push (Design per BAC 5972)	Design per BAC 5972)	MOMINAL SIZE:	3/8 inch
MAX. DIA. MANDREL:	L. 0.3580 inch	th MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.015 inch/inch	0.015 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL:	TEST MATERIAL: 300 'M' Steet (280/300 ksi) STACK UP	0 ksi) STACK UP:	3/8 inch

ole :afc.)	Bot.	0110	0110					
Retained hole expansion (catc.)	Mid.	0155	0160	l ole				
Reverse	Top	0185	0185	oze in hi removal				
Sleeve	thin out			Mandrel froze in hole – Broke on removal				
Force	for Mandret	19,260	23,800	29,000				-
Upset	of hole							
Upset	of hole							
Finish	after CW	1	ഹ	l				
٨.	Bot.	3515	3515					
Size after CW	Mrd.	3500	3505					
Siz	Top	3530	3530					
Maximum	(calc.)	.0235	.0235	.0235				
Finish prior	to CW	-	20					
.w.	Bot	3345	3345	3345				
Size prior to CW*	Mid	3345	3345	3345				
Size	Top	3345	3345	3345				
Hole	or O	E3	E4	E5				

PHASE I-TASK I-MANDREL TAPER DETERMINATION

The second and the second second

TEST NUMBER: 1D1S	TEST PLATE NUMBER:	XIII
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE:	3/8 inch
MAX. DIA. MANDREL: 0.3580 inch	MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.030 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP.	STACK UP:	3/8 inch

-				 			T	_	1	 ٦
lc.)	Bot.	5600	9600	0000	0075					
Retained hole expansion (calc.	Mid.	0000	0075	9000	9900					
Ret	Тор	0085	0075	00700	9900					
Sleeve	thin out			0100	0100					
Force required	for Mandrel	6080	5220	5200	4800					
Upset	of hole									
Upset	of hote									
Finish	after CW									
•>	Bot.	3535	3535	3515	3520					
Size after CW*	Mid.	3510	3515	3500	3505					1
Size	Top	3535	3525	3505	3510					
Maximum	(calc.)	.0140	.0140	.0145	.0140					
Finish prior	to CW	ı	04	45	l					
.w:	Bot.	3445	3440	3445	3445					1
Size prior to CW*	Mid	3440	3440	3534	3440					
Size	Тор	3440	3440	3435	3455					1
Hole	ė	A2	A3	B1.	82					1

PHASE I - TASK I.-MANDREL TAPER DETERMINATION

TEST NUMBER: 1E1S	TEST PLATE NUMBER:	XIII
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE:	3/8 inch
MAX. DIA. MANDREL: 0.3580 inch	MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.030 inch/inch	LUBRICATION	Fel Pro 300
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP	STACK UP.	3/8 inch

				 		 	 	 1
ن. ان و	Bot.	0140	0135	0120	0130			
Retained hole expansion (calc.)	Mid.	0110	0120	9600	0010			
Retexpa	Top	0120	0120	0010	0105			
Sleeve	thin out			.0015	.0015			ut.
Force	for Mandrel	6,640	6,680	13,100	9,200			sleeve thino
Upset	of hole							not include
Upset	of hole							ansion does
Finish	after CW							**Sleeve used; maximum expansion does not include sleeve thinout.
. >	Bot.	3535	3535	3515	3515			used; m
Size after CW*	Mid	3500	3500	3485	3485			Sleeve
Size	Тор	3515	3515	3495	3495			
Maximum	(calc.)	.0190	.0200	0610.	.0195			
Finish prior	to CW	80	ì	96	l			
, M	Bot	3395	3390	3395	3385			
Size prior to CW*	Med	3390	3380	3390	3385			05 inch
Size	Тор	3395	3395	3395	3390			*To nearest 0 0005 inch
Hole	ē	5	23	01	20			To ne

PHASE I-TASK I-MANDREL TAPER DETERMINATION

TEST NUMBER: 1F1S	TEST PLATE NUMBER: XIII	XIII
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE:	3/8 inch
MAX. DIA. MANDREL: 0.3580 inch	MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.015 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL: 300 'M' Steet (280/300 ksi) STACK UP.	STACK UP:	1-3/8 inch

					T			Γ—		1
ie alc.)	Bot	0600	3900							
Retained hole expansion (calc.)	Mid.	3065	9025							
Ret	dol	0070	0065			} 				
Sleeve	thin out	Mandrel Broke	Sleeve tor .0025 (est)							
Force	for Mandret	006'6	22,600						1 	
Upset	of hole									
Upset	of hole									
Finish	after CW									
, >	Bot.	3535	3505		!					
Size after CW*	Mid.	3505	3475							:
Size	Top	3520	3500							
Maximum	(calc.)	.0140	.0130							
Finish prior	to CW	40	40							
, ;;	Bot.	3465	3440		}	i				
Size prior to CW"	Mid	3440	3450		† : !					05 inch
Size	Top	3450	3495							To nearest 0 0005 inch
I c	2	A8	75							Tong

The state of the s

PHASE I-TASK I-MANDREL TAPER DETERMINATION

TEST NUMBER: 1F2S	TEST PLATE NUMBER:	XIII
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE:	3/8 inch
MAX, DIA, MANDREL: 0.3580 inch	MANDREL MATERIAL: Cerboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.030 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP:	STACK UP:	1-3/8 inch

e • Ic.)	Bot.	0000	90085	0095					
Retained hole* expansion (calc.)	Mid	0070	90075	0075					
Ret. expa	Тор	90085	0085	0075					
Steeve	thin out								
Force	for Mandrel	7000	6230	7780					
Upset	of hole								
Upset	of hole								
Finish	after CW								
. >	Bot	3530	3530	3530					
Size after CW*	Mid	3510	3515	3520					
ŠiŠ	Тор	3525	3530	3525					
Maximum	(calc.)	.0140	.0140	.0140					
Finish prior	to CW	1	l	45					
	ē	3440	3445	3440					
Size prior to CW	Mid.	3440	3440	3445					OS moch
Size	Top	3440	3445	3455					To pearest 0 0005 unch
Hole	e e	A6	A7	PA.					T.

PHASE 1-TASK I-MANDREL TAPER DETERMINATION

XIII	3/8 inch	Carboloy 883 (GF	Fel Pro 300	1-3/8 inch
TEST PLATE NUMBER: XIII	NOMINAL SIZE:	MANDREL MATERIAL: Carboloy 883 (GE)	LUBRICATION:	STACK UP:
1F3S	MANDREL: Push (Design per BAC 5972)	L: 0.3580 inch	0.0045 inch/inch	TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP:
TEST NUMBER: 1F3S	MANDREL: Push (MAX. DIA. MANDREL: 0.3580 inch	MANDREL TAPER: 0.0045 inch/inch	TEST MATERIAL:

	Bot.		010 c	0095						
role :								 	 	1
Retained hole expansion (calc.)	Mid.		0075	9075	-	<u> </u>				
Ret	Тор		090	6075						
Sleeve	thin out		-							
Force required	for Mandrel		0009	5400						
Upset	of hole	tole								
Upset	of hole	Mandrel Broke in Hole								
Finish	after CW	Mandre		1 - 1						
*>	Bot.		3535	3535	-					
Size after CW*	Mid.		3515	3515						
Size	Тор		3520	3520	·					
Maximum	(calc.)		.0145	.0140						
Finish prior	to C₩			40			·			
.M.	Bot.	3445	3435	3440						
Size prior to CW*	Mid.	3440	3445	3440				 		O5 inch
Size	Top	3445	3240	3440	American profession and			 		To nearest 0.0005 inch
Hole	S.	83	ro zi	<u>ពេ</u> ពា				ŕ		io ne

PHASE I- TASK I MANDREL TAPER DETERMINATION

11	3/8 inch	rboloy 883 (GE)	Fel Pro 300	1·3/8 inch
TEST PLATE NUMBER: XIII	NOMINAL SIZE: 3/	MANDREL MATERIAL: Carboloy 883 (GE)	LUBRICATION	
TEST NUMBER: 1G2S	MANDREL: Push (Design per BAC 5972)	MAX. DIA. MANDREL: 0.3580 inch	MANDREL TAPER: 0.030 inch/inch	TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP:

								 		
او . اد.)	Bot.	0140	0140	0140				 _		
Retained hole expansion (calc.)	Mid.	0110	0110	0115						
Ret: expar	Top	0140	0135	0130						
Sleeve	thin out				-					
Force	for Mandrel	9520	0096	9700						
Upset	of hole									
Upset	of hole									
Finish	after CW			,					}	
٠	Bot.	3530	3530	3530						
Size after CW	Mid	3495	3495	3495			} }			
Size	Тор	3520	3515	3515				 		
Maximum	(calc.)	.0195	.0195	.0200						
Finish prior	10 CW	1	l	100						
	Bot	3390	3390	3390						
Size prior to CW*	Mid.	3385	3385	3380		 		 		
Size	Top	3380	3380	3395						
Hole	ē.	9	2	క						

PHASE I-TASK I-MANDREL TAPER DETERMINATION

TEST NUMBER: 1G3S	TEST PLATE NUMBER: XIII	XIII
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE	3/8 inch
MAX. DIA MANDREL: 0.3580 inch	MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.045 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP	STACK UP:	1:3/8 inch

_				 	 			
le.)	Bot.	0150	ر ، وڊ					
Retained hole expansion (calc.)	Mid	0120	0125			-		
Retexpa	Тор	0140	0145					
Sleeve	thin out		Mandrel Broke					
Force	for Mandrei	8360	0008					
Upset	of hole							
Upset	of hole							
Fraish	after CW							
٧.	Bot.	3535	3540					
Size after CW*	Mid	3510	3515					
Siz	dol	3530	3520					
Maximum	(calc.)	.0190	0190					
Finish prior	to CW	١	8					
λν.	Bot.	3385	3380				-	
Size prior 10 CW*	Mid	3390	3390					
Size	Top	3390						
Hole	Ou	D3	D4					

PHASE I.-TASK I.-MANDREL TAPER DETERMINATION

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TEST NUMBER: 1J1S	TEST PLATE NUMBER:	VIX
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE:	3/4 inch
MAX. DIA. MANDREL: 0.7280 inch	MANDREL MATERIAL:	Carboloy 883 (GE)
MANDREL TAPER: 0.015 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP:	STACK UP:	2 inch

								 		 ì
آو. اد.)	Bot.	0125	0125						:	
Retained hole * expansion (calc.)	Mid.	0600	0600							
Ret	Тор	0100	0100	' : !						
Sleeve	thin out		Mandrel Broke							
Force required	for Mandret	48,100	24,100							
Upset	of hole									
Upset	of hole									
Finish	after CW								,	
>	Bot.	7200	7205							
Size after CW	Mid	7165	7170				 			
3	Top	7175	7185	 						
Maximum	(calc.)	.0205	.0200							
Finish prior	to CW	l	25	 	i !					
, An	Bot	7075	7080							
Size prior to CW	Mid	7075	7080	<u> </u>						OS Joch
Size	Top	7075	7085							To nearest 0 0005 unch
Hole	5	A2	A3							T.

PHASE I-TASK I-MANDREL TAPER OCTERMINATION

TEST NUMBER: 1J2S	TEST PLATE NUMBER: XIV	BER:	ΧΙΛ
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE: 3/4 inch	3/4 inch	
MAX. DIA. MANDREL: 0.7280 inch	MANDREL MATE	RIAL:	MANDREL MATERIAL: Carboloy 883 (GE)
MANDREL TAPER: 0.030 inch/inch	LUBRICATION: Fet Pro 300	Fet Pro 300	
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP		2 inch	

_											
ic.)	Bot.	0120	0120	0120	0120						
Retained hole expansion (calc.)	Mid.	0600	0600	0600	3600						
Ret expa	Тор	0105	0100	0100	0010						
Sleeve	thin out		_								
Force	for Mandrel	20,700	26,100	18,350	17,050						
Upset	of hale					-					
Upset	of hole										
Finish	after CW							_			
.,	Bot.	7200	7200	7200	7200						
Size after CW*	Mid.	7170	0/1/	0/11	7175						
Size	Тор	7185	7180	7180	7185						
Maximum	(calc.)	.0200	.0200	.026	.0200						
Finish prior	to CW	_	25	l	1				:		
,,,,	Bot.	7080	7080	7080	7080	_					
Size prior to CW*	Mrd.	7080	7080	7080	C80Z					_	
Size	Тор	7080	7080	7080	7080	-					
Hole	по.	83	84	23	ខ						

PHASE I-TASK I-MANDREL TAPER DETERMINATION

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	÷.	Carboloy 883 (GE)	300	
ΧIX	3/4 inch	Carbol	Fel Pro 300	2 inch
TEST PLATE NUMBER:	NOMINAL SIZE:	MANDREL MATERIAL:	LUBRICATION:	STACK UP:
TEST NUMBER 1J3S	MANDREL: Push (Design per BAC 5972)	MAX. DIA. MANDREL: 0.7280 inch	WANDREL TAPER: 0.045 inch/inch	TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP

ish Upset Upset required Sleeve expansion (calc.) CW of hole of hole Mandrel Top Mid. Bot. 14,900 0100 0095 0120	0100 0095	14,850 0110 0100 0125				
Upset Upset Force Sleeve entrance exit for thin out Tc of hole of hole Mandrel T4,900 01	0100	0110				
Upset Upset Force Sleeve entrance exit for thin out To of hole of hole Mandrel T4,900 01						
Upset Upset Force entrance exit for of hole of hole Mandrel 14,900	14,600	14,850				
Upset Upset entrance exit of hole of hole	14,600	14,850				
Upset entrance of hole						
	+					
es S						
Finish after CW						
8 ot. 7200 7200	7200	7205				
Size after CW* Mid. 80 7175	7175	7180				
Size Top 7180	7180	7190				
Maximum expansion (calc.)	.0200	.0200				
Finish prior to CW	3	l				
7080 7080	7080	7080				
Size prior to CW* OBO 7080 76 OBO 7080 76	7080	7080		-		
Size r Top 7080 7080	7080	7080				
5 G G		D4				

PHASE INTASK I - MANDREL TAPER DETERMINATION

TEST PLATE NUMBER: XVI	3/4 inch	MANDREL MATERIAL: Carboloy 863 (GE)	Fel Pro 300	2 inch
TEST PLATE NU	NOMINAL SIZE:	MANDREL MATE	LUBRICATION	STACK UP:
TEST NUMBER: 1K1S	MANDREL: Push (Design per BAC 5972)	MAX. DIA. MANDREL: 0.7280 inch	MANDREL TAPER: 0.015 inch/inch	TEST MATERIAL: 300 W Steel (280/300 kg) STACK UP:

Hole	Sze	Size prior to CW"	CW.	Finish prior	Maximum	Size	Size after CW*	٠,	Finish	Upset	Upset	Force required	Sleeve	Ret	Retained hole expansion (calc.)	e • (c.)
ξ	Top	Mid	Bot	to CW	(calc.)	1op	Mid	Bot.	after CW	of hole	of hole	for Mandrel	thin out	Тор	Mıd.	Bot.
A1	7030	7030	7035	 	0520	7155	7150	7200	í			23,000		0125	0120	0165
A2	7035	i		S	.0245	7160	7155	7195	25			32,900		0125	0120	0160
A3	7030	7035	7030	l ;	.0245	7165	7155	7200	1			43,300		0135	0120	0170
A4	7030	7035	7040	1	.0245	7160	7155	7200	١			40,000		0130	6120	0160
B 2	7030		7030	-	.0245	7170	0912	7210				45,800		0140	0130	0180
	To new set 0 0005	715 15.15														

PHASE I. TASK I-MANDREL TAPER DETERMINATION

TEST NUMBER: 1K2S	TEST PLATE NUMBER	XVI
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE:	3/4 inch
MAX. DIA. MANDREL: 0.7280 inch	MANDREL MATERIAL:	Carboloy 883 (GE)
MANDREL TAPER: 0.030 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL 300 'M' Steel (280/300 ksi) STACK UP	STACK UP	2 inch

Hole	Size	Size prior to CW*	C.v.	Finish prior	Maximum	Siz	Size after CW*	. Λ	Finish	Upset	iasdU	Force required	Sleeve	Ret	Retained hole expansion (calc.)	le* Ic.)
ę	Top	Mid	Bot	10 C.W	(cafc.)	Тор	Mrd	Bot.	after CW	of hole	of hole	for Mandref	thin out	Тор	Mid.	Bot.
B3	7030	7035	7030	09	.0245	7165	7155	7195	25			27,350		0135	0120	0165
84	7030	i		ı	.0245	7165			**			20,800		0135	0120	0165
ច	7035		7030	l	.0245	7165	7160	7200	١			22,500		0130	0125	0170
8	7035	7035	7045	ì	.0245	7175	7160	7205	ŀ			40,500		0140	0125	0160
8	7030	7035	7035	l	.0245	3117	7165	7205	1			45,900		0145	0130	0170
<u>;</u> 																
														1		
c	In nearest 9,0005 inch	005 inch														

PHASE I-TASK I-MANDREL TAPER DETERMINATION

EST NUMBER: 1K3S	TEST PLATE NUMBER: XVI	XVI
AANDREL Push (Design per BAC 5972)	NOMINAL SIZE:	3/4 inch
AAX. DIA. MANDREL: 0.7280 inch	MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
AANDREL TAPER: 0.045 inch/inch	LUBRICATION:	Fel Pro 300
EST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP	STACK UP:	2 inch

L	Size	Size prior to CW*	℃	Finish prior	Maximum	Ž!S	Size after CW*	٠.	Finish	Upset	Upset	Force	Sleeve	Ret ехра	Retained hole expansion (calc.	e• lc.)
Тор		fMrd.	Bot	to CW	(calc.)	Тор	Mid.	Bot.	after CW	of hole	of hole	Mandrei	נחות סחנ	Тор	Mid.	Bot.
7030	6	7030	7030		.0250	0717	7155	7210				24,300	Mandrel Broke	0140	0125	0180
7030	, o	7035	<u> </u>	 	.0245	7165		<u>i. </u>	1			17,000		0135	0125	0170
2	7030	7030	<u> </u>	75	.0250	0717	<u></u>		æ			17,000		0140	0130	0175
2	7030	7035	7036	1	.0245	0717	7160	7200	ı			20,800		0140	0125	0110
~	7030	7030	7030	1	.0250	0/11/	7160	7215	ı			24,400		0140	0130	0185
1																
! [
l											_					
ļ	1	1			***************************************											

PHASE I - TASK I-MANDREL TAPER DETERMINATION

TEST NUMBER: 1L1S	TEST PLATE NUMBER: XV	x
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE:	3/4 inch
MAX, DIA MANDREL: 0,7280 inch	MANDREL MATERIAL:	Carboloy 883 (GE)
MANDREL TAPER: 0.015 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP	STACK UP:	2 inch

				 			 	_	
le* Ic.}	Bot.	3195							
Retained hole expansion (calc.)	Mid.	0180							
Ret expa	Тор	0185							
Sleeve	thin out	Mandrel Broke							
Force	for Mandrel	30,400							
Upset	of hole								
Upset	of hole								
Finish	after CW								
	Bot.	7175]			
Size after CW*	M id.	7145				Ì			
Sic	Top	7150							
M ximum	(calc.)	3150.							
Finish prior	To CW	125	i i						
.v.:	Bot	0869	† †						
Size prior to C.V.	Mid	6965							
Size	Top	6965							
Hole	0	A.							

PHASE I.. TASK I.-MANDREL TAPER DETERMINATION

TEST NIJMBER: 25	TEST PLATE NUMBER:	×
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE	3/4 Incai
MAX, DIA, MENDREL: 0.7280 inch	MANDREL LIATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.03C inch/inch	LUBRIC ATION:	Fel Pro 300
TEL MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP	STACK UP	2 inch

						 	 1		
le• alc.}	Bot.	0220	0215	0210					
Retained hole expansion (calc.)	Mid.	0185	0185	0180					
Ret	Top	0200	0205	0200					
Sleeve	thin out								
Force	for Mandrel	24,300	23,500	24,500					
Upset	of hole				Hole				
Upset	of hole				Mandrel Broke in Hole				
Finish	after CW				Mandre				
· -	Bot.	7180	7180	7180	ı				
Size after CW*	Mid.	7145	7145	7145	ı				
Size	Тор	7165	7170	7165	1				
Maximum	(calc)	.0320	.0320	.0315	.0315				
Finish erior	o CW	l ;	125	ı	ı				
Ž	3ot.	39AO	5969	6970	0269				
Size prior to SW	Nrd.	J969	1	6965	6965				
22.5	3	5963	969	965	5969				
Hole	ę	82	83	8	5				

PHASE I-TASK I-MANDREL TAPER DETERMINATION

TEST NUMBER: 1L3S	TEST PLATE NUMBER	۸x
MANDREL: Push (Design per BAC 5972)	NOMINAL SIZE:	3/4 inch
MAX. DIA. MANDREL: 0.7280 inch	MANDREL MATERIAL: Carboloy 883 (GE)	Carboloy 883 (GE)
MANDREL TAPER: 0.045 inch/inch	LUBRICATION:	Fel Pro 300
TEST MATERIAL: 300 'M' Steel (280/300 ksi) STACK UP:	STACK UP:	2 inch

ile" alc.)	Bot.	0220	0220		 			
Retained hole expansion (calc.)	Mid.	0185	0185					
Ret	Тор	0210	0210					
Sleeve	tnin out							
Force required	for Mandrel	19,800	21,500					
Upset	of hole			Hole				
Upset	of hole			Mandrel Broke In Hole				
Finish	after CW			Mandre				
-	Bot.	7180	7180	_				
S' e after CW*	Mid	7145	7145	1				
υ.	Тор	7170	7170	1				
Maximum	(calc.)	.0320	.0320	.0315				
Finish prior	to CW	l l	125	ı				
. M	Bot	0969	0969	0269				
Size prior to CW*	Mid	0969	0969	969				
Size	Top	0969	0969	6965		 		1
Hole	٤	ខ	ಶ	5		!		

NOMINAL EXPANSION VALUE: 0.025 in.

G	E٢	NER	AL	TE	ST	CC	7(IDI	TI	10	1	S
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DATE:	11/2/72		
 UNIE.	11/2/12		

1. Specimen Description

Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50 in. Hole spacing: 1.50 in. Edge margin: 0.75 in. Material: 2024 T-851 0.250 in. Material gauge: Surface Treatment: Shot peen Fastener: None

3. CW Process

Sleeve type: Axial Split

Sleeve thickness: 0.010 in.

Sleeve orientation: 0°

CW Mandrel: ST 5300-CBM- 12 -0-N

CW Mandrel Taper: 0.045 inch/inch

CW Mandrel Major Dia.:0.3540 in.

Lubrication: Fel Pro 300 (on sleeve)

2. Hole Preparation

Nominal hale size: 3/8 in.

Process: Drill, ream, CW & ream (1/64 in.)

2024 0.025-in. interference 30 ksi

4. Fatigue Conditions

Net stress: 30 ksi max.

Test load: 8650 lb

Load ratio: (R) = 0.1

Test Frequency: 6200/minute

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Vibraphore (36 kip)

n No.	No.		le Diame (inches)	ter	l .	le Fin (RHR)	ish	CW Expansion es)	Expansion (ss)	Failure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
Н	1	.3500	.3635	.3735	10	6		.0240	.0135	200+	
A1	2	.3500	.3635	.3735	15	12	-	.0240	.0135		.028 in. Bow cw (Counter didn't work)
#I	1	.3500	.3655	.3735	15	10	5	.0240	.0155		
A2	2	.3500	.3655	.3735	20	12	1	.0240	.0155	353	.022 in. Bow ' cw
11	1	.3500	.3635	.3735	20	14		.C 1 0	.0135	ar a	
А3	2	.3500	.3635	.3735	12	7	_	.0240	.0135	451	.024 in. Bow cw

				TES	ST NU	IMBER	:	HA			
			N	OMINA	LEXP	PANSI	ONV	/ALUE:	0.025 in		_
9	SENE	RAL TES	TCOND	ZUCITI				Į.	DATE:	11/2/72	,
1	. Sp	ecimen	Descript	ion				3. Ç\	N Process	s	
Hole spacing: 1.50 in. Edge margin: 0.75 in. Material: 2024 T.851 Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None CW Mandrel: ST 5300-CBM- CW Mandrel Taper: 0.045 incl CW Mandrel Major Dia.: 0.3 Lubrication: Fel Pro 300 (on											: 0.010 in. on: 0° T 5300-CBM- 12 -0. per: 0.045 inch/inch jor Dia.: 0.3530 in.
			ol hole si : Drill, 0.025-i		$\overline{}$		1/64 ir	<u>n.)</u>	Test lo Load re Test Fr Test Lo Test Er		(b) = 0.1 6200/minute
Š	, Š		le Diame (inches)	ter		ole Fin (RHR)	nish	CW Expansion	Expansion	Failure ands)	Origin of Failure
Specimen No	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks
1	1	.3505	.3650	.3740	55	20	30	.0225	.0145		
4	2	.3505	3660	.3740	50	25	35	.0225	.0150	275	, ,
									,		

TEST NUMBER:	118	
NOMINAL EXPANSIO	ON VALUE: 0.020 in.	
GENERAL TEST CONDITIONS	DATE: 11/2/72	

1. Specimen Description

Zero load transfer, 2 hole, no CSK
Configuration: Fig. 2
Width: 1.50 in.
Hole spacing: 1.50 in.
Edge margin: 0.75 in.
Material: 2024 T-851
Material gauge: 0.250 in.
Surface Treatment: Shot peen
Fastener: None

3. CW Process

Sleeve type: Axial Split
Sleeve thickness: 0.010 in.
Sleeve orientation: 0°

CW Mandrel: ST 5300-CBM- 12 -0-N

CW Mandrel Taper: 0.045 inch/inch

CW Mandrel Major Dia.:0.3540

Lubrication: Fel Pro 300 (on sleeve)

2. Hole Preparation

Nominal hole size: 3/8 in.

Process: Drill, ream, CW & ream (1/64 in.)

2024 0.020-in, interference 30 ksi

4. Fatigue Conditions

Ner stress: 30 ksi max

Test load: 8650 lb

Load ratio: (R) = 0. !

Test Frequency: 6200/minute

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Vibraphore (36 kip)

n No.	No.		e Diame inches)	ter	1	le Fin (RHR)	ish	l CW Expansion res)	ed Expansion es)	s Failure ands)	Origin of Failure
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.3550	3655	.3735	8	6	-	.0190	.0105	400	
B1	2	.3550	3655	.3735	10	8	-	.0190	.0105	422	.020 in. Bow cw
Н	1	.3545	3640	.3735	10	8	-	.0195	.0095	200	
В2	2	.3545	3640	.3735	10	8	10	.0195	.0095	206	.038 in. Bow cw
11	1	.3550	3665	.3735	8	6	-	.0190	.0105		
вз	2	.3550	.3660	.3735	12	10		.0190	.0110	256	16 in Bow cw

TEST NUMBER: 1	IB
NOMINAL EXPANSION V	'ALUE: 0.020 in.
GENERAL TEST CONDITIONS	DATE: 11/2/72
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50 in. Hole spacing: 1.50 in. Edge margin: 0.75 in. Material: 2024 T-851 Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None	Sleeve type: Axial Split Sleeve thickness: 0.010 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -0-N CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.:0.3539 in. Lubrication: Fel Pro 300 (on sleeve)
2. Hole Preparation Nominal hole size: 3/8 in. Process: Drill, ream, CW & ream (1/64 in the size) 2024 0.020-in. interference 30 ksi	A. Fatigue Conditions Net stress: 30 ksi max In.) Test load: 8650 lb Load ratio: (R) = 0.1 Test Frequency: 6200/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibraphore (36 kip)
	

, oZ	No.	1	le Diame (inches)	ter	ı	le Fin (RHR)	ish	CW Expansion es)	Expansion ss)	o Failure ands)	Origin of Failure
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual CM Diametrical Exp (Inches)	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.3550	.3660	.3740	45	18	30	.0189	.0110	310	
В 4	2	.3550	.3645	.3735	50	20	35	.0189	.0095	310	

TEST NUMBER:	110
•	IIC
NOMINAL EXPANSION	ON VALUE: 0.015 in.
GENERAL TEST CONDITIONS	DATE: 11/2/72
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK	Sleeve type: Axial Split
Configuration: Fig. 2	Sleeve thickness: 0.010 in.
Width: 1.50 in.	Sleeve orientation: 00
Hale spacing: 1.50 in.	CW Mandrel: ST 5300-CBM - 12 -0-
Edge margin: 0.75 in.	CW Mandrel Taper: 0.045 (nch/inch
Material: 2024 T-851	CW Mandrel Major Dia.: 0.3540 in.
Material gauge: 0.250 in.	Lubrication: Fel Pro 300 (on sleeve)
Surface Treatment: Shot peen	
Fastener: None	
2. Hole Preparation	4. Fatigue Conditions
Nominal hole size: 3/8 in.	Net stress: 30 ksi max
Process: Drill, ream, CW & ream (1/6	/64 in.) Test load: 8650 lb
	Load ratio: $(R) = 0.1$
2024	Test Frequency: 6200/minute
0.015-in. interference	Test Laboratory: Materials
30 ksi	Test Engineer: D. Reese

Test Machine:

Vibraphore (36 kip)

No.	No.		e Diame inches)	ter	l .	le Fin RHR)	ish	CW Expansion es)	Led Expansion (2)	· Failure ands)	Origin of Failure
Specimen	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.3600	.3665	.3740	5	4	-	.0140	.0065		
C4	2	.3600	.3650	.3735	8	5	-	.0140	.0065	113	.026 in. Bow cw
11	1	.3600	.3665	.3735	10	8	10	.0140	.0065		
C2	2	.3600	.3650	.3740	10	8	-	.0140	.0050	148	.010 in. Bow cw
11	1	.3600	.3650	.3740	8	5	-	.0140	.0050		
СЗ	2	.3600	3650	.3735	10	6	_	.0140	.0050	105	.016 in. Bow cw

	TEST NUMBER:	IID	
	NOMINAL EXPANSIO	N VALUE: 0,010 in.	
GEI	NERAL TEST CONDITIONS	DATE: 11/2/72	
1.	Specimen Description	3. CW Process	
	Zero load transfer, 2 hole, no CSK Configuration Fig. 2 Width: 1.50 in. Hole spacing: 1.50 in. Edge margin: 0.75 in. Material: 2024 T-851 Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None	Sleeve type: Axial Split Sleeve thickness: 0.010 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -C CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.:0.3540 in. Lubrication: Fel Pro 300 (on sleeve)	1- C
2	Hale Preparation	4 Fatique Conditions	

Nominal hole size: 3/8 in.

Process: Drill, ream, CW & ream (1/64 in.)

2024 0.010-in, interference 30 ksi

Net stress: 30 ksi max Test load: 8600 lb Load ratio: (R) = 0.1Test Frequency: 6200/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibraphore (36 kip)

No.	Zo.	Hol (ter	Hole Finish (RHR)		ol CW al Expansion hes)	hed Expansion 15)	Failure ands)	Origin of Failure		
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.3650	.3680	.3735	15	10	- 2	.0090	.0030	50	
D1	2	.3650	.3680	.3735	18	12		.0090	.0030	50	.002 in. Bow cw
11	1	.3650	.3670	.3735	24	15	10	.0090	.0020	68	
D2	2	.3650	.3680	.3735	20	14		.0090	.0030	00	.004 in. Bow cw
13	1	.365 0	3680	.3735	18	10		.0090	.0030		
D3	2	.3650	3680	د 372.	25	14		.0090	.0030	73	.011 in. Bow cw

TEST NUMBER:		HE		
NOMINAL EXPANSION	N VALUI	0,035 in,		
GENERAL TEST CONDITIONS		DATE:	11/2/72	
1. Specimen Description	3.	CW Process		
Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3.00 in. Hole spacing: 3.00 in. Edge margin: 1.50 in. Material: 2024 T-851 Material gauge: 0.375 in. Surface Treatment: Shot peen Fastener: None		Sleeve oriel CW Mandre CW Mandre CW Mandre	kness: <u>0.015 in.</u> ntation: 00	-0 ve)
2. Hole Preparation Nominal hole size: 3/4 in, Process: Drill, ream, CW & ream (1/6) 2024 0.035-in. interference 30 ksi		Fatigue Condition Net stress: Test load: Load ratio: Test Frequer Test Loborat Test Enginee Test Machin	25,400 lb (R) 0, 1 (Cy: 6500/minute ory: Materials	-
				_

. oZ u	Š.	Hol	l .	Hole Finish (RHR)			Expansion (s)	Failure ands)	Origin of Failure		
Specimen	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Retained Diametrical Exp (Inches)	Cycles to Fail (Thousands)	and Remarks
11	1	.7115	.7320	.7480	25	15	25	.0349	.0205	20.4	
E4	2	.7115	.7320	.7480	30	18	20	.0349	.0205	394	
u	1	.7120	.7320	.7485	35	18	25	.0344	.0200	424	
ES	2	.7125	.7320	.7475	45	20	25	.0339	.0195	431	

				TEST	NUM	ABER:	ER: IIE				
			NC	MINAL	EXPA	NSIO	N VA	ALUE:	0.035 in	·	
G	ENER	AL TEST	CONDI	IONS				D	ATE:	11/2/72	
١.	Spe	cimen D	escriptio	οn				3. CW	Process		
2	ž. H	Configur Width: Hole spa Edge ma Material Material Surface Fastener ole Prep Nomina	rgin:	Fig. 3 3.00 in 3.00 in 1.50 in 2024 T 0.375 in None	-851 n. een				Sleeve of Sleeve of Sleeve of Sleeve of Sleeve of CW Mark CW Mark Lubrica of CW Mark C	ndrel Tape ndrel Maje tion: Fe ditions ess: 40 ksi ad: tio: (R	0.015 in. n: 0° 5300-CBM- 24 -0-N er: 0.045 inch/inch or Dio.:0.7164 in. I Pro 300 (on sleeve) max 33,777 lb) = 0.1 8000/minute Materials
		Hol	e Diame	ter	ì	le Fin	ish	sion			Vibraphore (36 kip)
No.	9	(inches)		((RHR)		S. Expa	Expans	Foilur ands)	Origin of Failure
Specimen Na.	Hole No.	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual CW Diametrical Expansion (Inches)	Retained Diametrical Expa (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.7115	.7335	7480	45	16	30	.0349	.0220		
E-1	2	.7115	.7340	7480	45	14	25	.0349	.0225	49	.034 in. Bow cw

				/ • •	
>	loken	at	WILLIEGE	(midpoint)	Ì

TEST NUMBER:	HE
NOMINAL EXPANSION	VALUE: 0.035 in.
GENERAL TEST CONDITIONS	DATE: 11/2/72
1. Specimen Description	3. CW Process
Zerc load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3.00 in. Hole spacing: 3.00 in. Edge margin: 1.50 in. Material: 2024 T-851 Material gauge: 0.375 in. Surface Treatment: Shot peen Fastener: None	Sleeve type: Axial Split Sleeve thickness: 0.015 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 24 -0 CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.: 0.7164 in. Lubrication: Fel Pro 300 (on sleeve)
2. Hole Preparation	4. Fatigue Conditions
Nominal hole size: 3/4 in. Process: Drill, ream, CW & ream (1/64 2024 0.035-in. interference 35 ksi	Net stress: 35 ksi max 4 in.) Test load: 29,500 lb Load ratio: (R) = 0,1 Test Frequency: 8000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibraphore (36 kip)

No.	No.	į	le Diame (inches)	ter	1	le Fin (RHR)	ish	CW Expansion es)	ed Expansion es)	, Failure ands)	Origin of Failure
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks
П	1	.7115	.7340	.7480	35	16	35	.0349	.0225	***	
E2	2	.7115	.7340	.7480	35	12	32	.0349	.0225	112	.029 in. Bow Grip failure
11	1	.7115	.7340	.7480	40	10	28	.0349	.0225	107	
E 3	2	.7115	.7335	.7480	45	12	30	.0349	.0220	107	.027 in. Bow cw

TEST NUMBER:	IIF	
nominal expansion	VALUE: 0.0315 ± 0.0015 in.	
GENERAL TEST CONDITIONS	DATE:	
1. Specimen Description	3. CW Process	
Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3,00 in, Hole spacing: 3,00 in, Edge margin: 1.50 in, Material: 2024 T-851 Material gauge: 0.375 in, Surface Treatment: Shot peen Fastener: None	Sleeve type: Axial Split Sleeve thickness: 0,015 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 24 -0 CW Mandrel Taper: 0,045 inch/inch CW Mandrel Major Dia.: 0,7164 in. Lubrication: Fel Pro 300 (on sleeve))-N
2. Hole Preparation	4. Fatigue Conditions	
Nominal hole size: 3/4 in. Process: Drill, ream, CW & ream (1/64 2024 0.032-in. interference	Load ratio: (R) = 0.1 Test Frequency: 6500/minute Test Laboratory: Materials	-
30 ksi	Test Machine: <u>Vibraphore (36 kip)</u>	

o Z o Z		1	e Diame (inches)	ter	Hole Finish (RHR)			I CW Expansion nes)	ned Expansion es)	Cycles to Failure (Thousands)	Origin of Failure
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Ext (Inches)	Cycles to Fail (Thousands)	and Remarks
	1	.7140	,7340	.7480	44	20	30	.0324	.0200	202	
F-1	2	.7140	.7340	.7480	50	25	35	.0324	.0200	392	,012 in, Bow cw
13	1	.7165	.7345	7480	40	20	12	.0304	.0180		
F-2	2	.7140	.7340	.7480	45	20	15	.0324	.0200	285	.009 in. Bow cw
11	1	.7150	.7345	.7480	45	20	25	.0314	.0195		*
F-3	2	.7140	.7340	.7480	45	25	30	.0324	.0200	360	,022 in, Bow cw

			PHASE	I - TA	SK 2 -	- OPTI	MUM	EXPAN	ISION D	EFINITIO	N	
				TEST	NUN	ABER:		HG				•
			NC	MINAL	EXPA	NSIO	N VA	LUE:	0,0265 ±	0,0055 in,		
G	ENER	AL TEST	CONDIT	IONS				D	ATE:1	1/2/72		
. 1.	Spe	cimen D	escriptio	n			;	3. CW	Process			
3)	Configur Width: Hole spa Edge ma Material Material Surface Fastener ole Prep Nominal	cing: rgin: : gauge: Treatmen	Fig. 3 3.00 ir 3.00 ir 1.50 ir 1.50 ir 2024 T-85 0.375 ir 1: Shot p None	n,				Sleeve Sleeve CW Ma CW Ma	ndrel Tape ndrel Majo tion: Fe ditions ess: 30 k ad: 25,5	0.015 in,	
			0.027-in.	2024 interferer IO ksi	nce				Test Fre Test La Test En	equency: <u>6</u> boratory: <u>N</u> gineer:	500/minute Materials), Reese Vibraphore (36 kip)	- - - -
Š.	No.	(inches) (R			ole Fin (RHR)	nish	CW Expansion	Retained etrical Expansion (Inches)	ycles to Failure (Thousands)	Origin of Failu	re	
pecimen No.	Hole	re CW	r Cw	ream	e CW	. C≪	Ream	Actual CW metrical Expo (Inches)	Retained etrical Ext	ycles to Fail (Thousands)	and Remarks	

No.			e Diame inches)	ter	Hole Finish (RHR)			CW Expansion es)	Expansion (s) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1	Origin of Failure	
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Ex (Inches)	Cycles to Fail (Thousands)	and Remarks
11	1	.7195	.7345	.7480	20	12	28	.0269	.0150	245	Grip failure
G1	2	.7195	.7345	.7480	14	8	25	.0269	.0150	245	,020 in, Bow
11	1	.7195	.7345	.7480	10	8	75	.0269	.0150	297	
G2	2	.7195	.7350	.7480	23	10	70	.0269	.0155	281	,020 in, Bow cw
	1	.7195	.7350	.7480	26	12	20	.0269	.0155	20.7	
G3	2	.7195	.7345	.7480	16	10	25	.0269	.0150	297	,010 in, Bow cw

				TEST	r NUA	ABER:		шн		-					
			NO	JANIMAL	. EXPA	NSIC	N V	ALUE:	0.025 in.						
G	ENER	AL TEST	CONDI	TIONS				D	ATE:	11/2/72					
١.	Spe	ecimen [Descriptio	o n				3. CW	Process						
Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3.00 in. Hole spacing: 3.00 in. Edge margin: 1.50 in. Material: 2024 T-851 Material gauge: 0.375 in. Sleeve type: Axial Split Sleeve thickness: 0.015 in. CW Mandrel: ST 5300-CBM- 24 -0 CW Mandrel: ST 5300-CBM- 24 -0 CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.: 0.7164 in. Lubrication: Fel Pro 300 (on sleeve) Surface Treatment: Shot peen Fastener: None															
2	2. Hale Preparation 4. Fatigue Conditions														
	2. Hole Preparation 4. Fatigue Conditions Nominal hole size: 3/4 in. Process: Drill, ream, CW & ream (1/64 in.) 2024 0.025-in. interference 35 ksi Test Laboratory: 6500/minute Test Laboratory: Materials Test Engineer: D, Reese Test Machine: Vibraphore (36 kip)														
No.	No.		e Diame inches)	}	le Fin (RHR)	ish	CW Expansion es)	ed Expansion s)	Failure Inds)	Origin of Failure					
Specimen No.	Hole N	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks				
11	1	.7 235	.7355	.7480	50	20	55	.0229	.0120						
н 1	2	.7235	,7350	.7480	32	15	40	,0229	,0125	55	.015 in, 8ow cw				

TEST NUMBER: NOMINAL EXPANSION		JE: 0.025 in.
GENERAL TEST CONDITIONS		DATE: 11/2/72
Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3.00 in. Hole spacing: 3.00 in. Edge margin: 1,50 in. Material: 2024 T-851 Moterial gauge: 0,375 in. Surface Treatment: Shot peen Fastener: None	3.	Sleeve type: Axial Split Sleeve thickness: 0.015 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 24 -0-1 CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.: 0.7164 in. Lubrication: Fel Pro 300 (on sleeve)
2. Hole Preparation Nominal hole size: 3/4 in. Process: Drill, ream, CW & ream (1/6) 2024 0.025-in. interference 30 ksi	4 . 64 in.)	Fatigue Conditions Net stress: 30 ksi max Test load: 25,400 lb Load ratio: (R) = 0.1 Test Frequency: 6500/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibraphore (36 kip)
	- -	

No.	No.	Before CW After CW After CW After Ream Actual CW Diametrical Expansion (Inches)		ter		Hole Finish (RHR)			Lxpansion	Failure ands)	Origin of Foilure
Specimen	Hole			Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks					
11	1	.7235	.7355	.7480	32	17	45	.0229	.0120	404	
H 2	2	.7235	.7355	.7480	50	25	42	.0229	.0120	164	,015 in, Bow cw
H	1	.7235	.7355	,7480	50	23	45	.0229	.0120	274	
н 3	2	.7235	.7355	.7480	40	16	30	.0229	.0120	214	.025 in, Bow cw
II H	1	.7230	.7340	.7480	35	15	20	.0234	.0110	101	
4	2	.7230	,7340	.7480	30	12	25	.0234	.0110	181	

				TEST	NUM	BER:		IIJ							
			NC	MINAL	EXPA	NSIO	N VA	LUE:	0.025 i	n					
GENERAL TEST CONDITIONS DATE: 11/10/72															
١.	Spe	cimen D	escriptio	n			;	3. CW	Process						
			d transfe		e, n o	CSK				ype: Ax					
		Configur	ation:	Fig. 2						hickness:					
		Width:		1.50 in						rientation	··				
		tole spa		1,50 in							5300-CBM- 12 -0-N				
		Edge mar		0.75 in						•	r: 0.045 inch/inch or Dia.: 0.3530 in.				
		Material		6A14V							1 Pro 300 (on sleeve)				
		Material Surface		0,250					LUBITCUI	ion. Te	1110 300 (oil steeve)				
Surface Treatment: Shot peen Fastener: None															
	,	asiciici	· ——	1 10/1/0											
2	2. Hole Preparation 4. Fatigue Conditions														
	1	Nominal	hole siz	.e: 3/8	in,				Net stre	ss: See rer	narks				
		Process:	Drill, r	eam, CV	V & re	am (1,	/64 in	.)	Test loo						
									Load rat) = 0.1				
			1	6AI-4V	- 1						6500/minute				
			0.025 i	n. interfere	ence					oratory:					
			60	and 70 ksi	j					ineer: D					
									Test Ma	chine: Vi	braphore (36 kip)				
1															
		Hol	e Diame	ter	Ho	le Fin	ish	c o	5 ^						
			e Diame	ter	ľ	le Fin	ish	nsion	Bion V	J.Fe					
<u>.</u>	•		e Diame inches)	ter	ľ	le Fin (RHR)	ish	W xpansion)	ponsion	ailure ds}	Origin of Failure				
No.	Š.			ter	ľ		ish 	I CW I Expansion nes)	ned Expansion es)	o Failure ands)	Origin of Failure				
men No.	le No.	(inches)		(RHR)		rual CW ical Expansion nches)	rained col Expansion ches)	s to Failure ousands)	Origin of Failure and				
ecimen No.	Hole No.	(inches)		(RHR)		Actual CW etrical Expansion (Inches)	Retained trical Expansion (Inches)	cles to Failure (Thousands)					
Specimen No.	Hole No.	(inches)		(RHR)		Actual CW ametrical Expansion (Inches)	Retained metrical Expansion (Inches)	Cycles to Failure (Thousands)	and				
Specimen No.	Hole No.	(ter ream	efore CW	RHR)	fter Ream	Actual CW Diametrical Expansion (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and				
= Specimen No.	Hole No.		inches)		(Oigmetrical Expansion (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and				
		Before CW	Affer CW	After ream	Before CW	After CW	After Ream	 			and Remarks				
		Before CW	Affer CW	After ream	Before CW	After CW	After Ream	 		Cycles to Failure (Thousands)	and Remarks				
11	1	Before CW	Age Case 3625	Ster ream	2 Before CW	OS After CW	Se After Reom	.0220	.0125	2,197	and Remarks 60 ksi (1st run)				
11	1	Before CW	Age Case 3625	Ster ream	2 Before CW	OS After CW	Se After Reom	.0220	.0125	2,197	and Remarks 60 ksi (1st run)				
11	1	Before CW	Age Case 3625	Ster ream	2 Before CW	OS After CW	Se After Reom	.0220	.0125	2,197	and Remarks 60 ksi (1st run)				
11	1	Before CW	Age Case 3625	Ster ream	2 Before CW	OS After CW	Se After Reom	.0220	.0125	2,197	and Remarks 60 ksi (1st run)				

	.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	TEST NUMBER:	113					
	NOM	INAL EXPANSI		E: 0.02	16 in.			
GENER	AL TEST CONDITIO	ONS		DATE:	1	1/10/72		
1. Sp	ecimen Description		3.	CW Proc	ess			
	Zero load transter, Configuration: Width: Hole spacing: Edge margin: Material: Material gauge: Surface Treatment: Fastener:	2 hale, no CSK Fig. 2 1,50 in. 1,50 in. 0,75 in. 6AI-4V Ti 0,0250 in. Shot peen		Slee Slee CW CW CW	ve thick: ve orien: Mandrel: Mandrel Mandrel	tation: ST 5300- Taper: 0.0 Major Dia	0 in. 0° -C BM - 12 945 inch/inch	-0- -ve)
2. H	Nominal hole size: Process: Drill, rea 6AI 0.025-in. ir 70	m, CW & ream (4 . <u>1/64 in</u> .)	Test Load Test Test Test	stress: load: fratio: Frequence Laborato Engineer	70 ksi max	nute Is	
	Hole Diameter	Hole Fi	nish	ansion	Ure			

No.	Zo.		le Diameter (inches)		Hole Finish (RHR)			CW Expansion es)	hed Expansion ss)	Failure ands)	Origin of Failure
Specimen	Hole	Bèfore CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.3505	.3625	.3735	60	35	25	.0215	.0120	932	
J2	2	.3505	.3625	.3735	70	30	20	.0215	.0120	932	
11	1	.3495	.3645	.3730	20	10	15	.0225	.0150	181	1
j4	2	.3495	.3645	.3730	_		-	.0225	.0150	101	Different mandrel cw useddia = ,3540 in.

				TEST	NUN	ABER:		IIJ			
			NO	DMINAL	EXPA	ANSIC	N V	ALUE: _	0,025	in.	
G	ENER.	AL TEST	CONDI	TIONS				ט	ATE:	11/10/72	
1.	Sp€	cimen D)escriptio	on				3. CW	Process		
2	1	Configui Width: Hole spo Edge mo Material Material	rgin: : : gauge: Treatmer	Fig. 3 1,50 1,50 0,75 6AI-4 0,250	in. in. in. in.	CSK		4. Fat	Sleeve Sleeve CW Ma CW Ma	ndrel Tape ndrel Maj tion: Fe	0.010 in.
		Nomina	Drill, r		W & r	eam (1	/64 in		Net stre Test loc Load ra Test Fre Test Lai Test Eng	ess: 80 ks ad: 23,10 tio: (R equency: boratory: gineer: (00 (b () = 0.1 6500/minute Materials
.07	No.	_	e Diame inches)	ter		le Fin (RHR)	ish	Actual CW netrical Expansion (Inches)	Led Expansion (ss)	Failure ands)	Origin of Failure
Specimen 140	Hole D	Before CW	Afrer CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Expa (Inches)	Cycles to Failure (Thousands)	and Remarks
\dashv											

Speci	유	Bèfore C\	Afrer CV	After rear	Before CV	After CM	After Rea	Act Diametri (1	Re Diametric (In	Cycle (Th	Remarks
11	1	.3505	.3625	.37 35	60	30	20	.0215	.0120	77	
J3	2	.3505	.3625	.3735	55	25	25	.0215	.0120	,,	cw

			PHASE				MUM	EXPAN	21014 DI	CHIMITIO	V
				TEST	NUN	ABER:		IIJ			
			NC	MINAL	EXPA	M210	NVA	ALUE:	0.025 in.		
G	ENER/	AL TEST	CONDI	IONS				DA	ATE: 11	/10/72	
1.	Spe	cimen D	escri p tio	on				3. CW	Process		
	1	Configur Width: Hole spa Edge mai Material Material	cing:	Sleeve (Sleeve (CW Mai CW Mai	thickness: orientation ndrel: ST ndrel Tape ndrel Majo	0.010 in. 1: 00 5300-C8M- 12 -0-1 1: 0.045 inch/inch 2: 0.3540 in. 1 Pro 300 (on sleeve)					
2	2. H	Fastener ole Prepi Nominal	hole siz	None (e: 3/8 i	n. W & re	eam (1			Test Lat	ress: 75 ksi d: 20,10 tio: (R equency: conutory: gineer: D	0 lb) 0. 1 6500/minute Materials
n No.	No.		e Diame inches)	ter	1	le Fin (RHR)	ish	Actual CW netrical Expansion (Inches)	Expansion es)	Cycles to Failure (Thousands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inche	Retained Diametrical Expansion (Inches)	Cycles to Fail (Thousands)	and Remarks
11	1	.3495	.3645	.3730	15	10	15	.0225	.0150		
J5	2	.3495	.3645	.3730	-	_	-	.0225	.0150	110	' cw

	TEST NUMBER:	IIK	
	NOMINAL EXPANSIO	N VAL	JE: 0.016 in.
GE	NERAL TEST CONDITIONS		DATE: 11/10/72
١.	Specimen Description	3.	CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1,50 in. Hole spacing: 1,50 in. Edge margin: 0,75 in. Material: 8AH4V T; Material gauge: 0,250 in. Surface Treatment: Shot peen Fastener: None		Sleeve type: Axial Split Sleeve thickness: 0.010 in. Sleeve orientation: 0° CW Mundrel: ST 5300-CBM-12 -(1-1) CW Mandrel Taper: 0.046 inch/inch CW Mandrel Major Dia.:0.3540 in. Lubrication: Fel Pro 300 (on sleeve)
2.	Hole Preparation Nominal hole size: 3/8 in. Process: Drill, ream, CW & ream (1/	4 . /64 in.)	Fatigue Conditions Net stress: 70 ksi max Test load: 20,200 lb
	6AI-4V 0.016-in. interference 70 ksi		Load ratio: (R) = 0.1 Test Frequency: 6500/minute Test Laboratory: Materials Test Engineer: D. Resse Test Machine: Vibraphore
			E .

											/ Jor aprior 4
، No.	le No.	Hole Diameter (inches)		ter	Hole Finish (RHR)		CW Expansion net.	o Failure Lands)	Origin of Failure		
Specimen	Hole P	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.3560	.3655	.3730	15	10	15	.0170	,0096		
K 4	2	.3560	.3660	.3730	-	-	-	.0170	.0100	196	cw
11	1	.3560	.3655	.3730	15	10	15	.0170	.0095		
5	2	.3560	.3655	.3730	-	-	-	.0170	.0095	94	, on

Edge margin. 0.75 in. CW Mandrel Taper: 0.045 inch/inch Material: 6AL4V TI CW Mandrel Major Dia.:0.3530 in. Material gauge: 0.250 in. Lubrication: Fel Pro 300 (on sle Surface Treatment: Shot peen Fastener: None 2. Hole Preparation 4. Fatigue Conditions Nominal hole size: 3/8 in. Net stress: 80 ksi max	1114761 - 1421/5 - 0111	MON EXITATION DELIMINATION
GENERAL TEST CONDITIONS DATE: 11/10/72 1. Specimen Description Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1,50 in. Hole spacing: 1,50 in. Edge margin: 0.75 in. Material: 6AH4V Ti Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None 2. Hole Preparation Nominal hole size: 3/8 in. DATE: 11/10/72 3. CW Process Sleeve type: Axial Split Sleeve thickness: 0.010 in. CW Mandrel: ST 5300-CBM- 12 CW Mandrel: ST 5300-CBM- 12 CW Mandrel: Taper: 0.045 inch/inch CW Mandrel Major Dia: 0.3530 in. Lubrication: Fel Pro 300 (on sleen) Surface Treatment: Shot peen Fastener: None 4. Fatigue Conditions Net stress: 80 ksi max	TEST NUMBER:	IIK
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1,50 in. Hole spacing: 1,50 in. Edge margin: 0,75 in. Material: 6AH4V Ti Material gauge: 0,250 in. Surface Treatment: Shot peen Fastener: None 3. CW Process Sleeve type: Axial Split Sleeve thickness: 0,010 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 CW Mandrel: ST 5300-CBM- 12 CW Mandrel Taper: 0,045 inch/inch CW Mandrel Major Dia: 0,3530 in. Lubrication: Fel Pro 300 (on sleepen Fastener: None 4. Fatigue Conditions Net stress: 80 ksi max	nominal expansio	N VALUE: 0.020 in.
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1,50 in. Hole spacing: 1.50 in. Edge margin. 0.75 in. Material: 6AL4V Ti Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None Zero load transfer, 2 hole, no CSK Sleeve type: Axial Split Sleeve thickness: 0.010 in. Sleeve thickness: 0.010 in. CW Mandrel: ST 5300-CBM- 12 CW Mandrel: ST 5300-CBM- 12 CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.:0.3530 in. Lubrication: Fel Pro 300 (on sleen) Fastener: None 4. Fatigue Conditions Net stress: 80 ksi max	GENERAL TEST CONDITIONS	DATE: 11/10/72
Configuration: Fig. 2 Width: 1,50 in. Hole spacing: 1,50 in. Edge margin: 0.75 in. Material: 6AL4V Ti Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None 2. Hole Preparation Nominal hole size: 3/8 in. Sleeve thickness: 0,010 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 CW Mandrel Taper: 0,045 inch/inch CW Mandrel Major Dia: 10,3530 in. Lubrication: Fel Pro 300 (on sleepen) Fastener: None 4. Fatigue Conditions	1. Specimen Description	3. CW Process
Nominal hale size: 3/8 in. Net stress: 80 ksi max	Configuration: Fig. 2 Width: 1,50 in. Hole spacing: 1,50 in. Edge margin: 0,75 in. Material: 6AH4V Ti Material gauge: 0,250 in. Surface Treatment: Shot peen	Sleeve thickness: 0.010 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 - CW Mandrel Taper: 0.045 inch/inch
	2. Hole Preparation	4. Fatigue Conditions
Load ratio: (R) 0.1 Test Frequency: 6500/minute 1.0020-in. interference 80 ks: Test Engineer: D. Reese Test Machine: Vibraphore (36 kip)	Nominal hole size: 3/8 in. Process: Drill, ream, CW & ream (1/6Al-4V 0.020-in. interference	Test load: 23,000 lb Load ratio: (R) 0, 1 Test Frequency: 6500/minute Test Laboratory: Materials Test Engineer: D, Reese

n Zo.	No.	Hole Diameter (inches)						CW Expansion es)	l Expansion hes) ned Expansion es)	Cycles to Failure (Thousands)	Origin of Failure
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Fail (Thousands)	and Remarks
П	1	.3560	.3635	.3730	60	30	20	.0160	.0075	58	
K1	2	,3560	.3635	.3730	70	35	16	.0160	.0075	30	cw

				TEST	NUM	BER:	IIK				
			NO	MINAL	EXPA	NSIO	N VA	LUE:	0.020 in.		
GE	NERA	L TEST	CONDIT	10N5				DA	TE:	1/10/72	
1.	Spe	cimen D	escriptio	n			:	B. CW	Process		
••	2 0 1 1 1 1 1	Zero load Configure Width: Hole spaid dge mar Material Material	d transfer ation: cing: gin: : gauge: Treatmen	Fig. 2 1,50 in 1,50 in 0,75 in 6AH4V 0,250 i	' Ti				Sleeve to Sleeve to Sleeve to CW Man CW Man	idrel: <u>ST</u> idrel Tope idrel Majo	0.010 in.
2	. Ho	ole Prepo	aration				4	1. Fati	gue Cana	ditions	
	ľ	Nominal	hole siz Drill, re 6 0.020 in		V & re	am (1/	/ 54 in.)	Load rat Test Free Test Lab Test Eng	io: 21,800 io: (R) quency: 68 oratory: N ineer: D	lb = 0.1 500/minute Materials
No,	No.		e Diame inches)	1	le Fin (RHR)	ish	CW Expansion es)	Expansion (s)	Failure ands)	Origin of Failure	
Specimen No	Hole I	Before CW	After CW	After ream	Before CW	After C',V	After Ream	Actual CW Diametrical Expansion (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and Remarks
11		.3555	.3635	.3730	80	45	20	.0165	.0080		
K2		.3365	.3635	.3730	75	35	15	.0160	.0075	113	cw
~											

	TEST NUMBER:	IIK	<u> </u>	
	NOMINAL EXPANSION	VALU	JE: 0.020 in,	
GE	NERAL TEST CONDITIONS		DATE: 11/10/72	
١.	Specimen Description	3.	CW Process	
	Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50 in. Hole spacing: 1.50 in. Edge margin: 0.75 in. Material: 6AI-4V Ti Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None		Sleeve type: Axial Split Sleeve thickness: 0.010 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -C CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.: 0.3530 in. Lubrication: Fel Pro 300 (on sleeve)) - N
2.	Nominal hole size: 3/8 in, Process: Drill, ream, CW & ream (1/6) 6Al-4V 0.020 in, interference 70 ksi	4 . 4 in.)	Net stress: 70 ksi max Test load: 20,200 lb Load ratio: (R) = 0.1 Test Frequency: 6500/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibraphore (36 kip)	-
7				_

No.	No.		e Diame inches)	ter	1	Hole Finish (RHR)			ol CW ol Expansion hes) ined I Expansion les)	o Failure sands)	Origin of Failure
Specimen	Hole 1	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.3565	.3635	.3730	60	30	15	.0155	.0070		
К3	2	.3555	.3635	.3730	75	40	20	.0165	.0080	224	cw
11	1	.3560	.3655	.3730	15	10	15	.0170	.009ö		
K4	2	.3560	.3655	.3730	-	-	-	.0170	.0100	196	Different mandrel cw used—dia = ,3540 in.

				TEST	NUM	ABER:		IIL				
			NC	MINAL	EXPA	NSIO	N VA	LUE: _	0.015 in.			
GE	NERA	AL TEST	CONDIT	IONS				D	ATE:	11/10/72		
١.	Spe	cime n D	escriptio	n			;	3. CW	Process			
Zero load transfer, 2 hale, no CSK Configuration: Fig. 2 Width: 1.50 in. Hale spacing: 1.50 in. Edge margin: 0.75 in. Material: 6Al-4V Ti Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None 2. Hale Preparation Nominal hale size: 3/8 in. Process: Drill, ream, CW & ream (6Al-4V 0.015-in. interference 70 ksi									Sleeve Sleeve CW Ma CW Ma Lubrica Sigue Con Net str Test Load ro Test Fre Test La Test Ener	ndrel Tape indrel Maj ition: Fe aditions ess: 70 ks ad: 20,2 ttio: (Fe equency: boratory: gineer: 1	5.0.010 in. 1.1	-
									lest Mo	chine: v	/ibraphore (36 kip)	_
cimen No.	No.	Hole Diameter Hole Fin						CW Expansion es)	Retained rical Expansion (Inches)	les to Failure Thousands)	Origin of Fail	ure
cimer	tole i	CW	≥ ∨	E	≯	>	e Gill	trical	Retained rical Exp (Inches)	les to Fail Thousands)	and Remarks	

Z Č	Zo.	Hole Diameter (inches)					CW Expansion es)	ed Expansion ss)	, Failure ands)	Origin of Failure	
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Reom	Actual C Diametrical Es (Inches)	Retained Diametrical Ex (Inches)	Cycles to Fail (Thousands)	and Remarks
11	1	.3615	.3650	.3730	80	45	15	.0105	.0035	102	
L1	2	.3615	.3650	.3730	70	45	20	.0105	.0035	102	cw
11	1	.3615	.3650	.3730	80	50	10	.0105	.0035	140	
L2	2	.3610	.3650	.3730	60	40	15	.0110	.0040	140	cw
11	1	.3610	.3650	.3730	50	35	20	.0110	.0040	05	
L3	2	.3615	.3650	.3730	60	40	15	.0105	.0035	95	cw

TEST NUMBER:	1IM	
 NOMINAL EXPANSION	VALUE:	0.010 in.

GENERAL TEST CONDITIONS

TIONS DATE: 11/10/72

1. Specimen Description

Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50 in. Hole spacing: 1.50 in, Edge margin: 0.75 in. Material: 6AI-4V Ti Moterial gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None

3. CW Process

Sleeve type: Axial Split
Sleeve thickness: 0.010 in.
Sleeve orientation: 0°
CW Mandrel: ST 5300-C8M- 12 -0-N
CW Mandrel Taper: 0.045 inch/inch
CW Mandrel Major Dia.: 0.3530
Lubrication: Fel Pro 300 (on sleeve)

2. Hole Preparation

Nominal hale size: 3/8 in.

Process: Drill, reum, CW & ream (1/64 in.)

6AI-1V 0.010-in. interference 70 ksi

4. Fatigue Conditions

Net stress: 70 ksi max

Test load: 20,100 ib

Load ratio: (R) = 0, 1

Test Frequency: 6500/minute

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Vibraphore (36 kip)

n No.	Zo.	Hole Diameter (inches)			Hole Finish (RHR)			I CW I Expansion nes) Expansion Expansion es)	o Failure ands)	Origin of Failure	
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Recm	Actual Diametrical (Inch	Retuined Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.3665	.3675	.3735	70	70	20	.0055	.0010	53	
M1	2	.3660	.3675	.3735	60	30	25	.0060	.0013	33	cw
11	1	.3660	.3675	.3735	60	35	18	.0060	.0015	57	
M2	2	.3660	.3675	.3735	70	40	25	.0060	0015	3,	cw
11	1	.3660	.3675	.3735	70	35	15	.0060	,0015	40	
МЗ	2	.3660	.3675	.3735	75	45	20	.0060	.0015	48	cw

	TEST NUMBER: NOMINAL EXPANSIOI	IIN V VALU	E: 0.035 in
GEN	NERAL TEST CONDITIONS		DATE: 11/10/72
1.	Specimen Description	3.	CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3,00 in. Hole spacing: 3,00 in. Edge margin: 1,50 in. Material: 6AI-4V Ti Material gauge: 0.375 in. Surface Treatment: Shot peen Fastener: None		Sleeve type: Axial Split Sleeve thickness: 0.015 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 24 -0-N CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.:0.7140 Lubrication: Fel Pro 300 (on sleeve)
2.	Hale Preparation Nominal hale size: 3/4 in.	4.	Fatigue Conditions Net stress: 70 ksi max
	Process: Drill, ream, CW & ream (1/s) 6AI-4V 0.035-in. interference 70 ksi	64 in.)	Test load: 60,300 lb Load ratio: (R): 0, 1 Test Frequency: 4500/minute Test Laboratory: Materials Test Engineer: D, Reese Test Machine: Vibraphore (100 kip)

No.	No.	Hole Diameter (inches)			Hole Finish (RHR)			CW Exponsion	Expansion (1)	Failure ands)	Origin of Failure
Specimen	ų ajoH	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical 5 (Inches)	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
¥1	1	,7095	.7290	.7485	100	45	20	.0325	.0195	405	
N1	2	.7095	.7290	.7485	-	-	-	.0325	.0195	105	cw
ı	1	.7095	.7290	.7485	-	-	~	.0325	.0195	05	
N2	2	.7095	.7290	.7485	-	_	_	.0325	.0195	65	cw
11	1	.7095	.7490	.7485	100	50	20	.0325	.0195	_	
N3	2	.7095	.7290	.7485	~	-	-	.0325	.0195	30	Discolored cw

	NOM	TEST NUMBER: NNAL EXPANSION	IIO V VALUE	E: 0.030 in.	
GE	NERAL TEST CONDITION	<u>SNC</u>		DATE: 11/10/72	
1.	Specimen Description		3.	CW Process	
	Zero load transfer,	2 hole, no CSK		Sleeve type: Axial Split	
	Configuration:	Fig. 3		Sleeve thickness: 0.015 in.	
	Width:	3.00 in.		Sleeve orientation: 00	
	Hole spacing:	3.00 in,		CW Mandrel: ST 5300-CBM-	24 -()-
	Edge morgin:	1.50 in.		CW Mandrel Taper: 0.045 inch/in	
	Material:	6Al-4V Ti		CW Mandrel Major Dia.:0.7140	
	Material gauge:	0.375 in,		Lubrication: Fel Pro 300 (on	sleever
	Surface Treatment:	Shot peen			
	Fastener:	Vone			
2	. Hale Preparation		4.	Fatigue Conditions	
	Nominal hole size	: 3/4 in.		Net stress: 70 ksi max	
		m, CW & ream (1/0	64 in.)	Test load: 60,200 lb	

6A1-4V 0.030-in. interference 70 ksi Net stress: 70 ksi max

Test load: 60,200 lb

Load ratio: (R) = 0, 1

Test Frequency: 4500/minute

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Vibraphore (100 kip)

No.	No.	l	e Diame inches)	ter	l	le Finish RHR)		CW Expansion			Origin of Failure
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Ex (inches)	Retained Diametrical Ex (Inches)	Cycles to Fail (Thousands)	and Remarks
11	1	.7130	.7295	.7485	80	35	10	.0290	.0165	95	
01	2	.7145	.7295	.7485	-		-	.0275	.0150	<i>83</i>	cw
11	1	.7130	.7295	.7485	_	_	_	.0290	.0165	78	
O2	2	.7140	.72 9 5	.7485	_		_	.0280	.0156		cw
11	1	.7130	.7295	.7485	90	45	15	.0290	.0165	60	
03	2	.7140	.7295	.7485	-		_	.0280	.0155	00	cw

	TEST NUMBER: NOMINAL EXPANSION	110 I VALUE: 0,030 in.	
GE	NERAL TEST CONDITIONS	DATE: 11/10/72	
١.	Specimen Description	3. CW Process	
	Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3.00 In. Hole spacing: 3.00 in. Edge margin: 1.50 in. Material: 6AI-4V Ti Material gauge: 0.375 in. Surface Treatment: Shot peen Fastener: None	Sleeve type: Axial Split Sleeve thickness: 0.015 in. Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 24 CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.: 0.7140 Lubrication: Fel Pro 300 (on sleev	-0-N ve)
2.	Nominal hole size: 3/4 in. Process: Drill, ream, CW (not postreamed) 6AI-4V 0.030-in. interference	4. Fatigue Conditions Net stress: 70 ksi max Test load: 60,100 lb Load ratio: (R) = 0, 1 Test Frequency: 4500/minute Test Laboratory: Materials	

Test Engineer: D. Reese

		·			J 				Test Ma		praphore (100 kip)
No.	, oZ	Hole Diameter (inches)			Hole Finish (RHR)			CW Expansion es)	Expansion (25)	Failure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	.7140	.7290	-	20	15	-	.0290	.0150	24	
04	2	.7140	.7290	-	25	20	-	.0290	.0150	95	cw
11	1	.7140	.7290	·-	25	20	-	.0290	.0150	95	
05	2	.7140	.7290	-	25	20		.0290	.0150		cw
							}				

> Taken at Minimum (midpoint)

70 ksi

	,	5 C C C C C C C C C C C C C C C C C C C	** =/**	11131011 DEI 111111011
	TEST	NUMBER:		IIP
	NOMINAL	EXPANSION V	ALUE:	0.025 in.
GE	NERAL TEST CONDITIONS		ı	DATE: 11/10/72
١,	Specimen Description		3. C	W Process
	Zero load transfer, 2 hole Configuration: Fig. 3 Width: 3.00 in. Hole spacing: 3.00 in. Edge margin: 1.50 in. Material: 6AI-4V Ti Material gauge: 0.375 in. Surface Treatment: Shotp Fastener: None			Sleeve type: Axial Split Sleeve thickness: 0.015 in. (thin out .001 i Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 24 - CW Mandrel Taper: 0.045 inch/inch CW Mandrel Major Dia.:0,7140 in. Lubrication: Fel Pro 300 (on sleeve
2.	Hole Preparation		4. Fa	atigue Conditions
	Nominal hole size: Process: Drill, ream, CW 6AI-4V 0.025-in interference 70 ksi	7		Net stress: 70 ksi max Test load: 60,300 lb Load ratio: (R) 0,1 Test Frequency: 4500/minute Test Laboratory: Materials Test Engineer: D, Reese Test Machine: Vibraphore (100 kip)
	Hole Diameter (inches)	Hole Finish (RHR)	V pansion	arsion ilure

. No.	So.	Hole Diameter (inches)			Hole Finish (RHR)			CW Expansion (es) hed Expansion		Failure ands)	Origin of Failure
Specimen	Hole !	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical E	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
	1	.7190	.7305	.7485	80	35	20	,0230	0115	50	
1	2	.7185	.7305	.7485	-	_		.0235	.0120	52	cw
11	1	.7185	.7305	.7485	-	-		.0235	.0120	7.4	
P 2	2	.7190	.7305	.7485		-	-	.0230	.0115	71	cw
11	1	.7190	.7305	.7485	80 /	35	20	.0230	.0115		
3	2	.7185	.7305	.7485	-		-	.0235	.0120	53	cw

				TEST	NUA	ABER:		IIQ				
			NC	MINAL	EXPA	NSIO	NV	ALUE: 0	.020 in.			
G	ENER	AL TEST	CONDI.	TIONS				D	ATE:11	/10/72		
١.	Spe	cimen D	escriptio	on				3. CW	Process		•	
	Zero load transfer, 2 hole, no CSI Configuration: Fig. 3 Width: 3.00 in. Hole spacing: 3.00 in. Edge margin: 1.50 in. Material: 6AI-4V Ti Material gauge: 0.375 in. Surface Treatment: Shot peen Fastener: None								Sleeve Sleeve CW Ma CW Ma	ndrel Tope ndrel Majo	0.015 in.	-0-l
2		ole Prep Nominal	aration hole siz	:e: 3/4	4 in.			4. Fati	igue Con Net stre		ksi max	
		Process:	0.020-in	eam , C\ Al-4V . interferer 70 ksi		eam (1	/64 in	.)	Test Lak Test Eng	tio: 60 equency: 4 coratory: 6 coratory: 6 coratory: 6	100 lb	
No.	Hole Diameter Hole Fi (inches) (RHR)					ish	CW Expansion	ted Expansion (s)	Failure inds)	Origin of Failur	е	
Specimen No.	Hole No. Before CW After ream After CW After CW		After CW	After Ream	Actual CW Diametrical Expansion (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and Remarks				
11	1	.7235	.7315	.7485			15	.0185	.0080	25		ţ, cw
α 1	2	.7240	.7316	.7485	·-	~	_	.0180	.0075	25		
П	1	.7235	.7315	.7485	-		-	.0185	.0080		الما أ	+

.0180

.0185

.0180

.0075

.0080

.0075

47

44

Taken at Minimum (midpoint)

.7240

.7235

.7240

.7315

.7315

.7315

.7485

.7485

.7485

Q

2

11

a

2

TEST NUMBER:	<u>ur</u>
NOMINAL EXPANSION	VALUE: NONE
GENERAL TEST CONDITIONS	DATE: 11/17/72
1. Specimen Description	3. CW Process (not used)
Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3,00 in. Hole spacing: 3,00 in. Edge margin: 1,50 in. Material: 6AL4V Ti Material gauge: 0.375 in. Surface Treatment: Shot peen Fastener: None	Sleeve type: Sleeve thickness: Sleeve orientation: CW Mandrel: CW Mandrel Taper: CW Mandrel Major Dia.: Lubrication:
2. Hole Preparation Nominal hole size: 3/4 in. Process: Drill and ream only 6AI-4V Reamed only 70 ksi	A. Fatigue Conditions Net stress: 70 ksi max Test load: 59,300 lb Load ratio: (R) = 0, 1 Test Frequency: 4500/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibraphore (100 kip)

. No.	Zo.	Hole Diameter (inches)			Hole Finish (RHR)			CW Expansion es)	Expansion (es)	Cycles to Failure (Thousands)	Origin of Failure
Specimen No.	Hole !	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Retained Diametrical Exp (Inches)	Cycles to Fail (Thousands)	and Remarks
R	1	-	-	.7510	-	~	25	-		38	
1	2	_	-	,7500		-	20	-		36	
11	1	~	-	.7500		-	25	~		28	
R 2	2	-		.7500	-	_	25	_	-	20	

TEST NUMBER: IIS

NOMINAL EXPANSION VALUE: 0.025 in.

GENERAL TEST CONDITIONS

DATE: 12/7/72

1. Specimen Description

Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50 in. Hole spacing: 1.50 in. Edge margin: 0.75 in. Material: 300 M steel Material gauge: 0.250 in, Surface Treatment: Shot peen Fastener: None

3. CW Process

2. Hole Preparation

Nominal hole size: 3/8 in.

Process: Drill, ream, CW & ream (1/64 in.)

300M 0.025-in, interference 110 ksi

Edges cupped on fracture surface from effect of shot peen; hole edges similar

4. Fatigue Conditions

Net stress: 110 ksi max

Test load: 31,400 lb

Load ratio: (R) = 0, 1

Test Frequency: 7000/min

Test Laboratory: Materials

Test Engineer: D. Reesc

Test Machine: Vibraphore (36 kip)

No.	No.	Hole Diameter (inches)			Hole Finish (RHR)			CW Expansion	Expansion	s Failure ands)	Origin of Failure
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retcined Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	0.3335	0.3505	0.3725	90	75	2 0	0.0245	0.0170	253	
S1	2	0.3335	0.3505	0.3725		-	-	0.0245	0.0170	255	cw
11	1	0.3330	0.3505	0.3725	85	70	25	0.0250	0.0170	240	
S2	2	0.3335	0.3505	0.3725	-	_	-	0.0245	0.0170	249	cw
Ħ	1	0.3335	0.3505	0.3730	90	75	60	0.0245	0.0170	126	
S 3	2	0.3335	0.3510	0.3725				0.0245	0.0175	135	cw Hole not cleaned up

	TEST NUMBER:	IIS	4
	nominal expansion v	/ALU	E: 0.021 in.
GE	NERAL TEST CONDITIONS		DATE: 11/27/72
١.	Specimen Description	3.	CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50 in. Hole spacing: 1.50 in. Edge margin: 0.75 in. Material: 300 M steel Material gauge: 0.250 Surface Treatment: Shot peen Fastener: None		Sleeve type: None used Sleeve thickness: Sleeve orientation: - CW Mandrel: Push (design per BAC 5972) CW Mandrel Taper: 0.045 in./in. CW Mandrel Major Dia.: 0.3580 Lubrication: Fel Pro 300
2.	Hale Preparation	4.	Fatigue Conditions
	Nominal hole size: 3.8 in. Process: Drill, ream, CW & ream (1/64 i 300M 0.021 in. interference	<u>n</u> .)	Net stress: 110 ksi max Test load: 31,300 lb Load ratio: (R) = 0, 1 Test Frequency: 4000/min Test Laboratory: Materials Test Engineer: D. Reese

Test Machine: Vibraphore (100 kip)

No.		Hol (Hole Finish (RHR)			CW Expansion es)	Expansion es)	Cycles to Failure (Thousands)	Origin of Failure		
Specimen	Hole I	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical	Retained Diametrical Exp (Inches)	Cycles to Fail (Thousands)	and Remarks
li .	1	0.3370	0.3510	0.3720	35	17	20	0.0210	0.0140	F	
S4A	2	0.3370	0.3510	0.3725	-	-	-	0.0210	0.0140	55	c/w
11	1	0.3370	0.3515	0.3720	30	15	20	0.0210	0.0145	44	
S5A	2	0.3370	0.3515	0.3720	-			0.0210	0.145	7.4	c/w

110 ksi

TEST NUMBER: 11 SB
NOMINAL EXPANSION VALUE: 0.023 in.

1. Specimen Description

Zero load transfer, 2 hole, no CSK

Configuration: Fig. 2

Width: 1.50 in.

GENERAL TEST CONDITIONS

Hole spacing: 1.50 in.

Edge margin: 0.75 in.

Material: 300 M steel

Material gauge: 0.250 in.

Surface Treatment: Shot peen

Fastener:

None

3. CW Process

Sleeve type: None used
Sleeve thickness:

Sleeve orientation: -

DATE: 11/27/72

CW Mandrel: Push (design per BAC 5972)

CW Mandrel Taper: 0.045 in./in.
CW Mandrel Major Dia.: 0.3580

Lubrication: Fel Pro 300

2. Hole Preparation

Nominal hale size: 3/8 in.

Process: Drill, ream, CW & ream (1/64 in.)

300M 0.023-in, interference 110 ksi

4. Fatigue Conditions

Net stress: 110 ksi max

Test load: 31,300 lb

Load ratio: (R) = 0.1

Test Frequency: 4000/min

Test Laboratory:

Materials

Test Engineer:

D. Reese

Test Machine:

Vibraphore (36 kip)

No.	Zo.	}	e Diame inches)	ter	CW (SHB) (SH		- Q-	o Failure ands)	Origin of Failure		
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch.	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	0.3350	0.3510	0.3720	30	15	20	0.0230	0.0160		
S6A	2	0.3350	0.3500	0.3720	1	-	-	0.0230	0.0150	Malfunction	cw
11	1	0.3350	0.3500	0.3720	35	18	20	0.0230	0.0150	144	
S7A	2	0.3350	0.3505	0.3720		_		0.0230	0.0155	144	cw

TEST NUMBER:

11	Т	

NOMINAL EXPANSION VALUE: 0.020

GENERAL TEST CONDITIONS

DATE: 12/7/72

1. Specimen Description

Zero load transfer, 2 hole, no CSK

Configuration: Fig 2

Width: 1.50 in

Hole spacing: 1.50 in.

Edge margin: 0.75 in.

Material: 300 M steel

Material gauge: 0.250 in.

Surface Treatment: Shot peen

Fastener: None 3. CW Process

Sleeve type: None used

Sleeve thickness: -

Sleeve orientation: -

CW Mandrel: Push (design per BAC 5972)

CW Mandrel Taper: 0.030 in./in.

CW Mandrel Major Dia.: 0.3580

Lubrication: Fel Pro 300

2. Hole Preparation

Nominal hale size: 3/8 in.

Process: Dill, ream, CW & ream (1/64 in.)

300M 0.020 in, interference 110 ksi

Failure edges corniced from shot peen effect

Fatigue Conditions

Net stress: 110 ksi max

Test load: 31,400 lb

Load ratio: (R) = 0.1

Test Frequency: 6000/4000/min

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Vibraphure (36 & 100 km)

n No.	, oZ	1	e Diame inches)	ter	Hole Finish (RHR)		CW Expansion es)	sed Expansion (25)	, Failure ands)	Origin of Failure	
Specimen	Hole	Bèfore CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrica! Ext (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	0.3390	0.3505	0.3725	60	50	15	0.0190	0.0115	77	
11	5	0.3390	0.3505	0.3725	_			0.0190	0.0115		cw 100 kip machine
11	3	0.3390	0.3510	0.3725	60	50	20	0.0190	0.0120	75	
Г2	2	0.3390	0.3510	0.3725			-	0.0190	0 0120	/5	as Sip machine
11	1	0 3390	0.3510	0.3725	60	45	15	0 0 1 9 0	0.0120	70	
13	2	0.3390	0.3510	0 3725				0.0190	0.0120	70 1	36 kip machine

	TEST NUMBER:	11 U	
	NOMINAL EXPANSION	VALU	DE: 0.015 in.
GE	NERAL TEST CONDITIONS		DATE: 12/7/72
١.	Specimen Description	3.	CW Process
	Zero load transfer, 2 hale, no CSK Configuration: Fig. 2 Width: 1.50 in. Hale spacing: 1.50 in. Edge margin: 0.75 in. Material: 300 M steel Material gauge: 0.250 in. Surface Treatment: Shot peen Fastener: None		Sleeve type: None used Sleeve thickness: - Sleeve orientation: - CW Mandrel: Push (design per BAC 5972) CW Mandrel Taper: 0.030 in./in. CW Mandrel Major Dia.: 0.3580 Lubrication: Fel Pro 300
2	. Hole Preparation	4.	Fatigue Conditions
	Nominal hale size: 3/8 in. Process: Drill, ream, CW & ream (1/6) 300M 0.015 in. interference	<u>i4 in.)</u>	Net stress: 110 ksi max Test load: 31,400 lb Load ratio: (R) = 0.1 Test Frequency: 7000/4000/min Lest Laboratory: Massials

Test Laboratory:

Test Engineer:

Materials

D. Reese

Test Machine: Vibraphore (36 & 100 kip)

, No.	Zo.		e Diame inches)	ter	l	le Fin (RHR)	ish	CW Expansion (es) led Expansion (s)		Failure ands)	Origin of Failure
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	0.3435	0.3515	0.3730	85	70	25	0.0145	0.0080	100	
UΊ	2	0.3435	0.3515	0.3730	-	_	_	0.0145	0.0080	100	c/w 36 kip machine
11	1	0.3435	0.3515	0.3725	85	70	20	0.0145	0.0080	67	
U2	2	0.3435	0.3515	0.3725		-	-	0.0145	0.0080	52	c/w 36 kip machine
11	1	0.3435	0.3515	0,3730	90	75	15	0.0145	0.0080	65	
U3	2	0.3430	0.3515	0.3730	-			0.0150	0.0085	\$5	c/w 36 & 100 kip machine

110 ksi

Failure edges corniced from shot peen effect

TEST NUMBER:	IIV	
NOMINAL EXPANSION	4 VALU	E: 0.010 in.
GENERAL TEST CONDITIONS		DATE: 12/7/72
1. Specimen Description	3.	CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 1.50 in. Hole spacing: 1.50 in. Edge margin: 0.75 in. Material: 300 M steel Material gauge: 0.250 in. Surface Treatment: Shat peen Fastener: None	**	Sleeve type: None used Sleeve thickness: - Sleeve orientation: - CW Mandrel: Push (design per BAC 5972) CW Mandrel Taper: 0.030 in./in. CW Mandrel Major Dia.: 0.3580 Lubrication: Fel Pro 300
2. Hole Preparation	4.	Fatigue Conditions
Nominal hole size: 3/8 in.		Net stress: 110 ksi max
Process: Drill, ream, CW & ream (1/6	34 in.)	Test load: 31,400 lb
		Load ratio: $(R) = 0.1$
300M 0.010 in. Interference		Test Frequency: 6500/min
110 ksi		Test Laboratory: Materials

Test Engineer:
Test L'achine:

D. Reese

Vibraphore (36 kip)

o Z		Hol	Hole Finish (RHR)			CW Expansion es)	ned Expansion es)	Cycles to Failure (Thousands)	Origin of Failure		
Specimen	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual CY Diametrical Ex (Inches)	Retained Diametrical Exp (Inches)	Cycles to Fail (Thousands)	and Remarks
11	1	0.3480	0.3525	0.3725	35	30	20	0.0100	0.0045	37	
V1	2	0.3480	0.3525	0.3725			-	0.0100	0.0045	3/	C∴M
11	1	0.3495	0.3525	0.3725	30	25	25	0.0085	0.0030		1
V2	2	0.3495	0.0325	0.3725		-	-	0.0085	0.0030	33	c/w Hole edge corniced one side
11	1	0.3490	0.3530	0.3725	30	25	40	0.0090	0.0040	22	
∨3	2	0.3495	0.3525	0.3725	~	-	-	0.0085	0.0030	33	, c/w

Failure edges corniced from shot peen

TEST NUMBER:	II W
NOMINAL EXPANSION V	/ALUE: 0.035 in.
GENERAL TEST CONDITIONS	DATE: 12/7/72
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 3 Width: 3.00 in. Hole spacing: 3.00 in. Edge margin: 1.50 in. Material: 300 M steel Material gauge: 0.375 in. Surface Treatment: Shot peen Fastener: None	Sleeve type: None used Sleeve thickness: - Sleeve orientation: - CW Mandrel: Push (design per BAC 5972) CW Mandrel Taper: 0.030 in./in. CW Mandrel Major Dia.: 0.7280 Lubrication: Fel Pro 300
2. Hole Prepuration	4. Fatigue Conditions
Nominal hale size: 3/4 in. Process: Drill, ream, CW & ream (1/64 i	Load ratio: (R) = 0.1
300M 0.035-in, interference 110 ksi	Test Frequency: 5000/min Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibraphore (100 kip)

No.		Hol	Hole Finish (RHR)			ctual CW rrical Expansion (Inches) etained cal Expansion Inches)		Failure ands)	Origin of Failure		
Specimen	Hole	Bèfore CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diamet cal Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
11	1	0.6920	0.7140	0.7495	35	30	10	0.0360	0 0220	53	
\V1	2	0.6925	0.7140	0.7495	_	-		0.0355	0.0215	53	c/w .
11	1	0.6920	0.7140	0.7495	30	25	15	0.0360	0.0220	80	
W2	2	0.6925	0.7140	0.7495				0.0355	0 0215	, 60 i	c/w
11	1	0.6920	0.7140	0.7495	40	35	10	0.0360	0.0220	50	
wз	2	0.6925	0.7140	0.7495				0.0355	0.0215	59	c.'w

TEST NUMBER: II X
NOMINAL EXPANSION VALUE: 0.030 in.

GENERAL TEST CONDITIONS

DATE: 12/7/72

1. Specimen Description

Zero load transfer, 2 hole, no CSK
Configuration: Fig. 3
Width: 3.00 in.
Hole spacing: 3.00 in.
Edge margin: 1.50 in.
Material: 300 M steel
Material gauge: 0.375 in.
Surface Treatment: Shot peen
Fastener: None

3. CW Process

Sleeve type:	
Sleeve thicknow	ess:
Sleeve oriento	
CW Mandrel:	Push (design per BAC 5972)
CW Mandrel 1	aper: 0.030 in./in.
CW Mandrel I	Major Dia.: 0.7280
Lubrication:	Fel Pro 300

2. Hole Preparation

Nominal hole size: 3/4 in.

Process: Drill, ream, CW & ream (1/64 in.)

300M 0.030 in, interference 110 ksi

4. Fatigue Conditions

Net stress: 110 ksi

Test load: 93,500 lb

Load ratio: (R) = 0.1

Test Frequency: 5000/min

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Vibraphare (100 kip)

Š	Zo.		e Diamet nches)	er		le Fini RHR)	ish	I CW I Expansion nes)	Expansion es)	Cycles to Failure (Thousands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual CN Diametrical Ex (Inches)	Retained Diametrical Ext (Inches)	Cycles t (Thou	Remarks
11	1	0.69 .5	0./165	0.7495	40	35	10	0.0295	0 0180	41	, , , , , , , , , , , , , , , , , , ,
X1	2	0.6985	0.7165	0.7495	-		-	0.0295	0.0180		
11	1	0.6985	0.7165	0 7495	40	35	15	0.0295	0.0180	43	
X2	2	0 6980	0.7165	0 7495			-	0.0300	0.0185	43	
11	1	0.6985	0.7165	0.7495	35	30	15	0.0295	0.0180	48	
х3	2	0.6980	0 / 165	0.7495	-	-		0.0300	0.0185	40	

Taken at Minimum (midpoint)

119

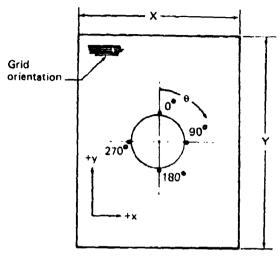
TEST NUMBER:	II Y
nominal expansio	ON VALUE: 0.025 in.
GENERAL TEST CONDITIONS	DATE: 12/7/72
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig.3 Width: 3.00 in. Hole spacing: 3.00 in.	Sleeve type: None used Sleeve thickness: _ Sleeve orientation: _ CW Mandrel: Push (design per BAC 5972)
Edge margin: 1.50 in. Material: 300 M steel Material gauge: 0.375 in. Surface Treatment: Shot peen Fastener: None	CW Mandrel Taper: 0.030 in./in. CW Mandrel Major Dia.: 0.7280 Lubrication: Fel Pro 300
2. Hole Preparation	4. Fatigue Conditions
Nominal hale size: 3/4 in. Process: Drill, ream, CW & ream (1 300M 0.025 in. interference 110 ksi	Net stress: 110 ksi max Test load: 93,400 lb Load ratio: (R) = 0.1 Test Frequency: 5000/min Test Laboratory: Materials Test Engineer: D. Reesc Test Machine: Vibraphore (100 kip)

No.	Ž	(le Diame inches)	ter	l .	ole Fin (RHR)	ish	CW Expansion es)	Fed Expansion (5)	Failure ands)	Origin of Failure	
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks	
11	1	0.7025	0.7170	0.7495	50	45	10	0.0255	0.0135	26	c/w	
Y1	2	0.7040	0.7165	0.7495	-	-	-	0.0240	0.0125	36		
11	1	0.7020	0.7165	0.7495	45	40	15	0.0260	0.0145	20		
Y2	2	0.7040	0.7170	0.7495		-	-	0.0240	0.0130	39	; c/w	
11	1	0.7035	0.7170	0.7495	45	40	10	0.0245	0.0135	24	1	
Y3	2	0.7025	0.7170	0.7495		-		0.0255	0.0145	31	c/w	

TEST NUMBER:	H Z
NOMINAL EXPANSION	N VALUE: 0.0
GENERAL TEST CONDITIONS	DATE: 12/7/72
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK	Sleeve type: None used
Configuration: Fig. 3	Sleeve thickness:
Width: 3.00 in.	Sleeve orientation:
Hole spacing: 3.00 in.	CW Mandrel: Push (design per BAC 5972)
Edge margin: 1.50 in.	CW Mandrel Taper: 0.030 in./in.
Material: 300 M steel	CW Mandrel Major Dia.: 0.7280
Material gauge: 0.375 in.	Lubrication: Fel Pro 300
Surface Treatment: Shot peen	
Fastener: None	
2. Hole Preparation	4. Fatigue Conditions
Nominal hole size: 3/4 in.	Net stress: 110 ksi max
Process: Drill, ream, CW & ream (1/6	
	Load ratio: (R) : 0.1
300M	Test Frequency: 5000/min
0.020-in, interference	Test Laboratory: Materials
110 ksi	Test Engineer: D. Reese
	Test Machine: Vibranhare (100 kin)

ó Z	ġ	Hole Diameter (inches)			Hole Finish (RHR)			CW Expansion es)	Led Expansion (3)	Failure ands)	Origin of Failure	
Specimen	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diometrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks	
11	1	0.7080	0.7175	0.7495	40	35	10	0.0200	0.0095			
21	2	0.7080	0.7175	0.7495	-	-		0.0200	0.0095	32	c/s	
μ	1	0.7080	0.7180	0.7495	40	35	10	0.0200	0.0100			
Z2	2	0.7080	0.7180	0.7495		-		0.0200	0.0100	64	l c/w	
11	1	0.7080	0.7175	0.7495	35	30	10	0.0200	0.0095	44		
Z 3	2	0.7080	0.7175	0.7495			_	0.0200	0.0095	44	l c/w	

PHASE I-TASK 2-MOIRE DATA



Specimen Configuration

View looking at exit side
Same reference maintained both sides, i.e., 90° on entrarice side
is opposite 90° on exit side
All strains are \mathbf{E}_{γ} component

· Area where strain was measured

			X (in.)	Y (in.)	³ ⊖ (deg)	Affected zone (in.)					
Specimen	Material	Hole				(Exit fac	ce)	(Entrance face)			
no.		size				·Y	+Y	·Y	+Y		
1	Al	Large	2.3	4.3	18	0.55	0.55	0.60	0.55		
2	AL		2.3	4.3	232	0.60	0.50	0.60	0.50		
3	Τi		2.8	3.0	38	0.65	0.65	0.65	0.65		
4	Ti		2.8	3.0	35	0.90	0.90	0.90	0.90		
5	Al	Small	1.5	4.3	160	0.45	0.35	0.45	0.30		
6	AL		_1.5	4,3	265	0,45	0.35	(b)			
7	Ţi		1,5	1,9	45	0.45	C.40	0.40	0.40		
8	Ti		1.5	1,9	50	0.40	0.36	0.35	0.35		
9	·Stl		1.5_	1.7	Not visible	0.40	0.35	0.35	0.30		

Specimen		ε_{ν}	(exit face)		Ey (entrance face)					
no.	0°	90°	180°	270°	0.0	90°	180°	270°		
_1	.094	.018	.020	.018	.063	.010	.029	.010		
2	,025	.018	.110	.028	.030	.012	.049	.011		
3	.125	.022	078	.025	.050	.016	.054	.010		
4	,094	.020	.055	.022	.032	.021	.031	.010		
5	.015	.036	.066	.023	.028	.018	.090	.020		
В	(b)									
7	.034	.034	.065	(b)	.045	,016	.062	.022		
8	,064	,029	.085	.011	.029	.015	.055	.019		
9	.082	.015	.066	.029	.071	.018	.059	.018		

⁼ Questionable because of split discontinuity effect

 $^{^{\}it a}$ Location of discontinuity from split in sleeve

^bDamaged; did not read

- 3

SPE	SPECIMEN 3F1	TEST 10/26/72
MATERIAL	300 M steel (280/300 ksi)	MANDREL MATERIAL: Vascojet 'MA'
MATERIAL STACKUP	3/8 inch	MANDREL TAPER (IN./IN.): 0.015
NOMINAL HOLE SIZE (IN.): 0.364 and 0.358	0.364 and 0.358	MANDREL MAX DIA (IN.) 0.3538 (start)
COLDWORK PROCESS:	Pull	SLEEVE THICKNESS (IN.) 0.0105
		LUBRICATION (SLEEVE): Fel Pro 300

Remarks (tool life operational success, etc.)		Mandrel had deep center.			Difficulty removing sleeve				
Mandrel	loss (in.)	None	None	0.0002	0.0004	0.0004	None		
Retained coldwork	expansion {in.}	0.0035	0.0025	0.0025	0.0045	0.0045	0.0045		
Sleeve	(in.)	0.0004	0.0004	0.0004	0.0006	0.0010	0.0015		
Pull	<u>a</u>	2600	2340	2520	2620	2630	2560		
Theoretical coldwork	expansion (in.) ³	0.0113	0.0113	0.0113	0.0166	0.0157	6.0153		
heter (in.)	After coldwork	0.3670	0.3660	0.3660	0.3635	0.3635	0.3635		
Hole diameter (in.)	Before coldwork	0.3635	0.3638	0.3635	0.3580	0.3585	0.3585		
Hole	Ou	Α1	42	А3	El	E2	E3		

^a Does not include allowance for mandrel diameter decrease or sleeve thinout

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Remarks (too) life operational success, etc.)					(Sleeve could not be removed from hole)				
Mandrel	loss (in.)	None	None	None	0.0006	0.0001	None		
Retained coldwork	expansion (in.)	0.0020	0.0025	0.0025		0.0045	0.0045		
Sleeve thinout (in.)		0.0010	0.0005	0.0005		0.0010	0.0010		
P _{ull}	(q _I)	3600	3230	3280	4670	2670	5140		
Theoretical coldwork diameter	expansion (in.) ^a	0.0108	9010:0	0.0108	0.0158	0.0152	0.0151		
Hole diameter (in.)	After coldwork	0396.0	0.3655	0.3655	See remarks	0.3625	0:3630		
Hole dian	Before coldwork	0.3630	0:3630	0.3630	0.3580	03580	0.3575		
Hole	ġ.	βĄ	A5	A6	E4	ES	E6		

^a Does not include allowance for mandrel diameter decrease or sleeve thinout

PHASE I-TASK 3 -COLDWORK PROCESS FOR STEEL

<u>}</u>.

6/72	3260		0.3538 (start)		
3 DATE 10/26/72	MANDREL MATERIAL A1S1 9260	MANDREL TAPER (IN /IN.): 0.015	MANDREL MAX DIA (IN.): 0.3538	SLEEVE THICKNESS (IN.) 0.0105	LUBRICATION (SLEEVE): Fel Pro 300
SPECIMEN 3F1 TEST	300 M steel (280/300 ksi).	3/4 inch	SIZE (IN.) .3640 and .3580	Pull	
SPE	MATERIAL	MATERIAL STACKUP:	NOMINAL HOLE SIZE (IN.)	COLDWORK PROCESS:	

Remarks (tool life operational success, etc.)							Sleeve could not be removed		
Mandrel	loss (in.)	0.0004	0.0004	0.0001	0.0007	0.0002	None		
Retained coldwork	expansion (in.)	0.0025	0.0030	0.0020	0.0045	0.0050			
Sleeve	(in.)	0.0010	0.0010	0.0010	0.0015	0.0015			
Puti	(16)	3940	3420	3740	4320	480∁	4460		•
Theoretical coldwork	expansion (in.) ^a	0.0118	0.0114	0.0110	0.0159	0.0147	0.0150		
Hole diameter (in.)	After coldwork	0.3655	0.3660	0.3650	0.3625	0.3625			
Hole diam	Before co!dwork	0.3630	0.3630	0:3630	0.3580	0.3585	0.3580		
Hole	ou Ou	A7	A8	181	Ε?	E 8	F1		

 $^{^{\}mathrm{d}}\mathrm{D}\mathrm{d}\mathrm{e}$ not include allowance for mandrel diameter decrease or sleeve thinout

PHASE I-TASK 3-COLDWORK PROCESS FOR STEEL

10/26/72	H-11 (nitrided) 0.015	0.3540 (start)	0.0105	Fel Pro 300	Remarks (tool life operational success, etc.)							
DATE	MANDREL MATERIAL:	MANDREL MAX DIA (IN.):	SLEEVE THICKNESS (IN.)	LUBRICATION (SLEEVE):	Mandrel diameter Remai		£.0058					
TEST4	MANDRE	MANDREI	SLEEVET	LUBRICA	Retained coldwork diameter	expansion (in.)	0.0030					
	300 ksi)				Sleeve	(in.)	None					
3F1	300 M steel (280/300 ksi) 3/4 inch	9			Pull	(q ₁)	4900					
SPECIMEN_		NOMINAL HOLE SIZE (IN.) 0.3580	SS: Putt		Theoretical coldwork	expansion (in.) ^a	0.0170					
	MATERIAL:	NAL HOLE SIZ	COLDWORK PROCESS:		Hole diameter (in.)	After coldwork	0.3510					
	MATE	NOM	COLD	•	Hole dian	Before coldwork	0.3580					
					Hole	٦٥.	F2					

11/6/72	Vascojet 'MA'		start)		
DATE: 11/		MANDREL TAPER (IN /IN.): 0.015	MANDREL MAX DIA (IN.): 0.3521 (at start)	SLEEVE THICKNESS (IN.) 0.0105	LUBRICATION (SLEGVE): <u>Fel Pro 300</u>
TEST5	MANDREL MATERIAL	MANDREL TAPE	MANDREL MAX	SLEEVE THICKN	LUBRICATION (S
SPECIMEN Fatigue coupon	4340 'M' (270/360 ksi)	0.20 inch	3/8	Pull	
SPI	MATERIAL:	MATERIAL STACKUP	NOMINAL HOLE SIZE (IN.)	COLDWORK PROCESS	

Remarks (tool life operational success, etc.)		Mandrel previously used for steel pull testing.						
Mandrel	lus s (in .)	None	None	None	None			
Retained coldwork diameter	expansion (in.)	0.0026	0.0065	0.0075	0.0066			
Sleeve	(m.)	0.0013	0.0035	0.0025	0.0025			
Pull	(91)	1880	3000	2175	2220			
Theoretical coldwork	expansion (in)a	0.0101	0.0191	0.0190	0.0190			
neter (in.)	After coldwork	0.3656	0.3605	0.3615	0.3606			
Hole diameter (in.)	Before coldwork	0.3630	0.3540	0.3540	0.3540			
Hole	Ö	-	2	е	4			

 $^{\mathrm{d}}\mathrm{Does}$ not include allowance for mandrel diameter decrease or sleeve thinout

TEST 6 DATE: 11/6/72	MANDREL MATERIAL AISI 9260	MANDREL TAPER (IN./IN.): 0.015	MANDREL MAX DIA (IN.): 0.3520	SLEEVE THICKNESS (IN.) 0.0105	LUBRICATION (SLEEVE): Fel Pro 300
SPECIMEN Fatigue coupon	MATERIAL: 4340 'M' (270-300 ksi)	MATERIAL STACKUP: 0.20 inch	NOMINAL HOLE SIZE (IN)	COLDWORK PROCESS: Pull	

Remarks (tool life, operational success, etc.)			Sleeve slid in jaws & crippled part of sleeve failed					
Mandrel diameter	loss (in.)	None	0.0002	None				
Retained coldwork diameter	expansion (in.)	900'0	0.0043	0.0070				
Steeve	(in.)	0.0030	0.0035	0:0030				
Putt	(g)	2:335	2875	2700				
Theoretical coldwork diameter	expansion (in.)	0.0190	0.0200	0.0198			:	
neter (in.)	After coldwork	0.3605	0.3573	0.3600				
Hole diameter (in.)	Before coldwork	0.3540	0.3330	0.3533				
Hole	Ö	-	2	~7				

 ${}^{\rm a}{\rm Does}$ not include allowance for mandrel diameter decrease or sleeve thinout

DATE: 11/21/72	Vascojet 'MA'	/IN.): 0.015	IN.): 0.3520 (start)	IN.) 0.0105	/E): Fel Pro 300		nemarks (tool life, operational success, etc.)	Mandrel tang broke-before it reached maximum diameter						
7	MANDREL MATERIAL:	MANDREL TAPER (IN./IN.)	MANDREL MAX DIA (IN.):	SLEEVE THICKNESS (IN.)	LUBRICATION (SLEEVE):_	Mandret	loss (in.)	l						
TEST	MANDRE	MANDRE	MANDRE	SLEEVE	LUBRICA	Retained coldwork	expansion (in.)	ł						
	300 ksi)_					Sleeve	(in.)	ţ						
3F1	300 M steel (280/300 ksi).	nch				Puil	(lb).	10,840						
SPECIMEN	300 N	P: 3/4 inch	E (IN.): 3/8	SS: Pull		Theoretical coldwork diameter	expansion (in.) ^a	0.0230				·		
	RIAL	MATERIAL STACKUP:	NOMINAL HOLE SIZE (IN.):	COLDWORK PROCESS:		leter (in.)	After coldwork	l						
	MATERIAL	MATE	NOMI	COLD	1 .	Hole diameter (in.)	Before coldwork	0.3500						
						Hole	no.	 -						

 ${}^{\mathrm{a}}\mathrm{Does}$ not include allowance for mandrel diameter decrease or sleeve thinout

	SPECIMEN 3F1	TEST 8 DATE: 11/21/72	1
MATERIAL	300 M steel (280/300 ksi)	MANDREL MATERIAL: AISI 9260	
MATERIAL STACKUP:	3/8 inch	MANDREL TAPER (IN./IN.): 0.0.5	ļ
NOMINAL HOLE SIZE (IN.): 3/8	IN.): 3/8	MANDREL MAX DIA (IN.): 0.3518	
COLDWORK PROCESS: Pull	Pull	SLEEVE THICKNESS (IN.) 0.0105	
		LIBRICATION (SLEEVE). Fol Pro 300	

Remarks (tool life, operational success, etc.)		Mandrel diameter decreased ton much for production process					
Mandret	toss (in.)	0500:0					
Retained coldwork	expansion (in.)	ļ					
Sleeve	(in.)	١					
Pull	(q)	4080					
Theoretical coldwork	expansion (in.)	0.0230					•
neter (in.)	After coldwork	ı					
Hole diameter (in.)	Before coldwork	0.3500					
Hole		-					

³ Does not include allowance for mandrel diameter decrease or sleeve thinout

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ALLOY 300M

Filing Code: SA-81 Steel-Alloy

MARCH 1959

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DATA ON WORLD WIDE METALS AND ALLOYS

Published by Engineering Alloys Digest, Inc. Upper Montclair, New Jersey

ALLOY 300M.

(Ultra-High Strength Steel)

ALLOY 300M is an alloy steel offering a combination of hardenability, ductility and toughness at tensile strengths from 280000 to 320000 psi.

> **Physical Constants:** Density, lb /cu. in.

> > Specific heat, BTU/lb/°F.

Modulus of clasticity, psi x 10⁶

Thermal coef. expansion/2F. x 10.6 (0.200°F). Thermal conductivity, BTU/ft²/in/hr/°F.

* U.S. Par. 2,191,500

Composition:

Carbon	0.40 - 0.45
Manganese	0.65 - 0.90
Silicon	1 45 - 1 80
Nickel	1 65 - 2 00
Chromium	0 65 - 0 90
Molybdenum	0 30 - 0 45
Vanadium	0 05 min
Phosphorus	0.025 mar.
Sulphur	0 025 max.
lron	Remainder

PROPERTIES Table 1 - EFFECT OF TEMPERING TEMPERATURE

			a., on quenches it	OEB 13.3 F.)		
Temperiog	Tensile	Yield	Charpy		Reduction	
Temperature	Strength	Strength	Impact	Elongation	of Area	Brinell
, <u></u>	_ pti	psi (0.2%)	ft. lbs.	% in 2"	%	Hardoess
200	340000	140000	13.0	6.0	10.0	375
400	110000	240000	16.0	7.0	27.0	555
500	<i>2</i> 97 0 00	242000	18.0	8.0	32.0	540
600	289000	245500	22.0	9.5	34.0	525
700	2H0000	235000	17.5	90	32.0	500
800	260000	215000	10.0	8.5	23.0	425
	Table '	TVPICAT	MECHANICAL	DRODERTIES SO	PCINC	

(Quenched in oil and tempered at 500°F.)

	Longitudinal	Transverse
Tensile scrength, psi	297000	196000
Notch tensile strength, psi	303000	262000
Yield strength, psi (0.2%)	242000	239000
Elongation, % in 2"	8.0	4.0
Reduction of area, %	23.0	9.4
Charpy impact, ft. lbs. (V-notch)		• • •
at room temp.	18	9
at -65°P.	15	7
Bend test*	•	
Load, Ibs.	10200	9650
Outside angle, deg.	35	25

* Load applied at center of 7.16 dia. x 5' long specimen supported near end

Table 3 - TYPICAL PROPERTIES OF WELDED TUBES

(56) dia x 4	wall, flash butt	welded tub	s, gil quenched	and	tempered at 400°F)
			Parent Met	al	Across the Wel

	Parent Metal	Across the Weld
Tensile strength, psi	302500	285600
Notch strength, pri	270000	246000
Elongarion, % in 2"	9	3
Reduction of area, %	18	7
Chargy impact, ft. lbs (V-notch)		
at room temp.	20	19
st 65°P.	18	14
Bend Test*		
Max. load, Ibs.	9800	8900
Charida band and a la-	14	74

Ourside bend angle, deg.

* Load applied to the center of 7 16 dia. by 5 long rounds supported near ends.

* Table 4— EFFECT OF MASS ON TENSILE PROPERTIES*

(Heat treated by normalization at 100 F, oil quenching from 1573 F, and tempering

	treat treated by normalizing at	1 OU T, oil quenching from	i 13-3 fr. and tempering at o	(H) F)
Ber	Tensile	Yield		Reduction
Diameter	Strength	Strength	Elongation	of Ares
inches	_ jsi	psi (0.2%)	% in 2"	%
i	280000	745500	9.5	34 1
3	281000	236000	9.5	350
5%	308000	261000	1.3	22.3

. Heat treated in full section.

Table 5 -- EFFECT OF MASS ON IMPACT PROPERTIES*

(Heat treated by normalizing at 1650 F., oil quenching form 1575 F. and tempering at 600 F.)

Bar Diameter	izod Impact ft. lbs.		Charpy Impact V-Notch, ft. lbs.	
inches	at + 70°F.	₹70°F.	·50 °F	·100°F.
i	23	72	19	18
3	15	19	14	?
* Heat treated in full section.	12	9	7	,

Table 6 --- NOTCH TENSILE TESTS

(414" squares, oil quenched and tempered at 600 F.)

		0.3" Diameter	0.5" Diameter
K factor = 10	Longitudinal	320000	275000
••	Transverse	315000	245000
K factor 5	Longitudinal	345000	307000
	Transverse	312000	312000
K factor: 3	Longitudinal	385000	358000
	Transverse	385000	335000

(Stress concentration "K" factors were varied by control of notch root radius. The factor for the sharp notch-less than

Table 7 - TYPICAL MECHANICAL PROPERTIES - CAST

(U.SOC Sand Cast Reel D	OCKS L X L X O)	
	Heat Treat A	Heat Treat B
Tensile strength, psi	257500	262000
Yield strength, psi (0.1%)	221250	221750
Elongation, % in 2"	5.8	5.9
Reduction of area, %	10.6	10.8
Charpy impact, ft. lbs. (V-notch) R. T.	10.5	11
0°F.	10	10
-50°F.	10	8
·100°F.	8	8

Heat Treat A-Austenitized at 1650°F, for one hour, transferred to a furnace at 1350°F, held at 1350°F, for 30 minutes, quenched in oil and double rempered at 600°F, for 6 hours. Hear Treat B-Austenitized at 1650°F, for one hour, transferred to a furnace at 1350°F, held at 500°F, for 5 minutes, air cooled, double tempered at 600°F. for 6 hours.

Heat Treatment:

Ar, 650°F. CRITICAL POINTS: Ac, 1400°F. Ar, 785°F. Ac, 1480°F.

(400°F./hr. heating and cooling rate)

ANNEALING: Heat to about 1430°F, and equalize, cool 10°F. hr. to 1200°F., 20°F./hr. to 900°F, and air cool for 241 Brinell maximum. (Produces a spheroidized structure.)

NORMALIZING: Heat to about 1700°F., air cool. Recharge in furnace before reaching room temperature.

HARDENING: Heat to about 1600°F, quench in oil, temper at 500-600°F. Double tempering is advisable.

(It is not recommended for any other tempering temperature. This range produces maximum yield strength and maximum impact strength simultaneously. Tempering on either side of the recommended range results in a serious deterioration of mechanical properties.)

Machinability:

Machinability rating of annealed material is 45% of cold-rolled B1112 screw machine stock. Can be machined without difficulty up to 250 Brinell. A partially spheroidized structure obtained by normalizing and drawing at 1200 deg. F. is best for optimum machinability.

Fligh speed steel cutting tools should be ground to 8-12 deg. side rake, 6-10 deg. back rake, 7-9 deg. side relief, 7-9 deg. end relief, 8-12 deg. end cutting-edge angle, about 15 deg. side cutting-edge angle, and a nose radius of about 10% of depth of cut. Sintered carbide cutting tools should be ground to 4.9 deg, side rake, 0.10 deg, back rake, 6.10 deg, side relief, 6.12 deg, end relief, 8.13 deg, end cutting-edge angle, 0.20 deg, side cutting-edge angle, and a nose radius equal

When machining stock around 200 Brinell hardness with high When machining stock around 200 Brinell hardness with high speed steel cutting tools use cutting speeds of 70 sfpm with feed of 0.060 in rev. and depth of cut of 1/32 inch; 120 sfpm with feed of 0.015 in. rev. and depth of cut of 1/32 inch, 60 sfpm with feed of 0.030 in. rev. and 1/4 inch depth of cut. With sintered carbide cutting tools use cutting speeds of 260 sfpm with feed of 0.060 in. rev. and depth of cut of 1/32 inch, 470 sfpm with feed of 0.015 in. rev. and depth of cut of 1/32 inch, 205 sfpm with feed of 0.030 in. rev. and depth of cut of 1/32 inch, 205 sfpm with feed of 0.030 in. rev. and depth of cut of 1/42 inch.

Manufacturori

Various alloy sizel mills (Licensed).

Workability:

Forge at 1950-2200°F, and allow to cool in air in a dry place. Forging should not be continued below 1700°F.

Weldability:

Good welding characteristics. Can be readily gas or arc welded. Welding rod of the same composition shall be used. In arc welding use a coated welding rod. The retarded grain growth during welding minimizes the normal ill-effects produced by grain coarsening. As the steel has air hardening properties the part after the welding shall be either annealed or normalized and drawn.

General Characteristics:

Tough, shock and impact resistant. Has best combination of duttility, toughness, and strength. High fatigue and creep resistant. This steel has air hardening properties and is especially free of temper-brittleness. Maintains good strength properties at elevated temperatures. Ware and abrasion resistant in excellent torque properties. Recommended for heavy duty, high strength applications.

high-strength applications. The most desirable properties of this steel are obtained by using a 600°F, temper after the oil quench. This treatment produces the best yield to tensile strength ratio and the best impact strength for all sizes tested. As shown by the impact data, the steel as tempered at 600°F, does not show any definite transition temperature range. There is a regular decrease in impact strength with decreasing temperature in the manner of 9% nickel steel.

of 9% nicket steel. Since tempering above 600°F, is not recommended, this steel should not be employed for service at higher temperatures. The hardenability of 300 M is so great that it may be hear treated in heavy sections without impairment of its properties. The lominy hardenability curve, being essentially horizontal for its full length, indicates that the hardenability is too great to be usefully evaluated by this test.

Forms Available:

Billets, bars, rods, forgings, sheet, strip, plate and castings.

Applications:

Aircraft landing gears, airframe parts, high strength bolts, hirings wing fasteners and pylon parts, carbide-bit bodies, drop forgings for various applications, axles, gears, shafting, pressure vessels, oil-well perforating guns.



AISI 9260

Filing Code: SA-167 Steel-Allay

SEPTEMBER 1964

AISI 9260 (Spring Steel)

DATA ON WORLD WIDE METALS AND ALLOYS-

Engineering Alloys Digstt, Inc.
Upper Montclair, New Jersey

AISI 9260 is an oil-hardening type of spring steel and tool seed recommended for repeated and severe impact service. It is also used for heavy duty, shock resistant machine parts.

Composition:

po=111011.		
	9260	9260H
Carbon	0.56-0.64	0.55-0.65
Manganose	0.75-1.00	0.65-1.10
Silicon	1.802.20	1.70-2.20
Phosphorus*	0.035 max	0.010 max
Sulphur*	0.040 max	0.040 max
Iron	Remainder	Remainder

Physical Constants:

Density, lb cu.in.	0.283
Thermal conductivity, Btu/ft ² /ft/hr/°F (212°F)	
Thermal coef. expansion/of (70-1200°F) x 10-6	8.1
Specific heat, Btu/lb/9F	0.10-0.11
Electrical resistivity, microhm-cm (68°F)	20
Modulus of elasticity, psi x 106 (in tension)	29.0
(in torsion)	10.7

Phosphorus and sulphur are 0,040 max in open hearth steel and 0,025 max in electric furnace steel.

PROFERTIES

Table 1 - TYPICAL MECHANICAL PROPERTIES

	Normalized	Annested
Tenule strength, pei	150000	118000
Yield screageh, par (0.2%)	80000	68000
Elongation, % is 2"	15	22
Reduction of area, %	30	.46
Brinell hardoess	311	241
Isod impact, (t. lbs.	3	,

Table 2 - TYPICAL HEAT TREATED PROPERTIES

		I http://worthwined.i	OUU F., QUENCING IN	0(1 17/3 F., WEEP	100 1	
Tempering	Tensile	Yield		Reduction		Isod
Temperature	Scrapth	Strength	Elongation	of Area	Brisell	i mpinet
``F.	pei .	psi (0.2%)	<u>% ia 2°</u>		Harjass	N. 184.
400	355000	330000		19	633	6
500	350000	330000	7	21	653	?
600	340000	325000	9	25	627	7
700	325000	280000	9.5	28	601	
800	260000	228000	10	30	514	12
900	215000	193000	11	31	429	13
1000	187000	166000	12	32.5	368	14
1100	165000	144000	15	35	341	24
1200	148000	125000	17	40	311	35
1100	120000	103000	20	47	269	39

Table 3 — MASS EFFECT DATA (5.7 Grain Sim, 0.61C., 0.82Ma, 2.11Si, 0.23Ce. 0.08Ni, 0.02Ma) (Bribithero—Single best results)

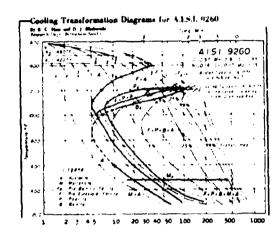
Tenaile Scrength	Yield Point	Plongation	Reduction of Arm	Brinell	land Impact
pei	pti	% is 2°		Hardness	ft. Res.
1575°F., futme		to 1280° F., air coo	led)		
	67250	14.5	20.2	262	2.5
	cooled)				
166730	98250	15.3	35.0	551	40
161000	90750	14.7	25.3	321	4.0
159300	87230	13.7	30.3	311	4.0
144000	86750	4.2	3.9	293	3.0
575°F., mappered	M 900°F.				
230300	207000	10.7	25.7		5.7
224500	200750	9.2	246		60
202000	168250	9.5	22.7		6.5
173250	105500	4.5	4.5	341	3 3
575°F., tempered	at 1100°F.				
177750					10
174250					8 7
160230	130500	16.0			# Z
149000	94230	105	19.2	321	3.2
	Strength pi 1575°E, furner 132230 to 1600°E, sir 166730 161000 199800 144000 975°E, empered 230800 173230 575°E, empered 177750 174230 160230	Tensik Strength Point Po	Tensik Yield Strength Point Elongation Point Point Filongation Point Point Filongation Point Filongation Point Filongation Point Filongation Point Filongation Point Filongation Point Filongation Point Filongation Point Filongation Point	Strength	Tensik Strength Point Elongation Garage Reduction of Area Related

Toble 4 — AS-QUENCHED HARDNESS DATA (Oil quenched from 1979*F.)

	Rockwell "C" Hardoos						
	V1 11.6	i" Rd.	2" Rd.	4' M			
Surface	64	62	60	42			
1.2 Radius	64	62	55	38			
Center	64	62	50	37			

Toble 5.- JOMINY HARDENABILLITY - 9260H ("J" distance in 1-16 inch)

"J" distance	1		3	4	5	6		н	10	12	16	20	24	32
Rc max.													36	
Rc min.	60	60	57	53	46	41	38	36	35	34	32	31	30	28



Heat Treatment:

Critical Points: Ac, 1440°F Ac, 1490°F

Ar₁ 1345°F Ar₁ 1330°F

Anneal: Heat to 1525-15750F, furnace cool. Normalize: Heat to 1600-16500F, quench.

Harden: Heat to 1575-16259F, quench in oil, temper to desired hardness.

Machinability:

Machinability rating of mill annealed stock (187-255 Brinell) is about 45% of AISI B1112 steel. To obtain best machining properties, heat to 1400-14500F, cool slowly to 10000F, then air cool.

Cobalt high-speed steel or carbide-tipped cutting tools are recommended. High-speed steel turning tools should be ground to 8-100 side rake, 6-80 back rake, 7-90 side relief, 7-90 end relief, 10-140 end cutting-edge angle, 12-160 side cutting-edge angle, and a nose radius equal to 10% of depth of cut. Carbide-tipped tools should be ground to 6-100 side rake, 2-60 back rake, 8-100 side relief, 8-100 end cutting-edge angle, 8-100 end cutting-edge angle, and a nose radius of 1/32 inch. For high-speed steel cutters use sulphurized or chlorinated cutting oils, but no cutting oil for carbide-tipped tools.

Specification Equivalents:

SAE 9260 QQ-S-624, FS9260 QQ-S-474, Comp. E. ASTM A59, Gr. 9260 ASTM 2314, Gr. 92601 MIL-S- 6-(10 Comp. 5

Workability:

Forge from 21.75°F, to 1.750°F. It is subject to decarburization and should therefore not be held at the forging temperature longer than is necessary. After forging, the serel should be cooled slowly by burying in ashes, dry time, silocel or other dry heat-insulation material.

Weldability:

The high carbon and slicon contents of this steel introduces difficulty in welding, which is therefore, not recommended mirrorally

Corresion Resistance:

This steel is better than plain carbon steel in industrial atmosphere and about the same when continuously exposed to mosture. If salts are present, corrosion is increased, it is arracked readily by acids, but resistant to alkalis at ordinary temperatures.

General Characteristics:

AISI 9260 is recommended for heavy duty springs and for shock resisting parts in which a combination of high ductility with hardness is required. The combined qualities of extremely high strength together with toughness gives this steel the ability to withstand repeated and severe impacts. It is primarily an oil-hardening steel, it may be quenched in water with satisfactory results, butcare should be taken if the part has drastic dimensional change or sharp conners. The higher oil-quenching temperature improves the strength, ductility, and shock-resistance. It has good wear-resistance and maximum shock-resistance for hardnesses under Rockwell C58.

Although it is not classed as a non-deforming steel, it will hold size and shape reasonably well during heat treatment, if normal precautions are used in its application and treatment. Where freedom from distortion is of primary importance, the parts should always be oil-quenched rather than water-quenched.

It decarburizes more freely than other tool steels when heated for forging, annealing, or heat treating. This is due to its high silicon and molybdenum content. Care should be exercised during heating to protect it from decarburization. This steel is less notch sensitive than either carbon steel or chromium-vanadium alloy steel.

Form Available:

Billets, bars, rods, forgings.

Applications

Heavy duty springs, shear blades, pneumatic tool, punches, shanks for carbide tools, machine parts subject to shock, chisels, caulking tools and all types of severe or unusual service involving drastic or repeated impact at atmospheric temperatures.

Manufacturer:

Practically all alloy steel mills.



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VASCOJET M-A (CVM)

Filing Code: SA-150 Steel-Alley

JULY 1963

DATA ON WORLD WIDE METALS AND ALLOYS

VASCOJET M-A (CVM) (Ultra High Strongth Steel)

Published by Engineering Alleys Digust, Inc. Upper Montdair, New Jerrey

Vascojet M-A (CVM) is an ultra high-attength alloy areal capable of reaching tensile strength values up to 360,000 psi and maintaining high attength levels at operating temperatures to 1000 deg. F. It combines extremely high attength with ductility, toughness, fatigue and heat resistance.

Composition:

Physical Constants:

Carbon	0.50-0.55	Specific gravity	7.92
Tungaten		Density, lb/cu.in. Thermal coef, expansion/oF = 10-6 (80-1000°F)	0.2 0 6.4
Molyhdenum T	otal 12.0	Modulus of elasticity, pai s 10°	0.4
Vanadium		at 70°F	31.0
Iron	Remainder	at 400°F	28.8
		4(1000°F	24.0

PROPERTIES

Table 1 - TYPICAL HEAT TREATED PROPERTIES (Standard 0.250" round buttonhead teasile specimens quenched from 2050 deg. F. in salt at 1050 deg. F. and triple tempered (2+2+2 hours) as indicated.)

Tempering Temperature of	Tensile Strength psi	Yield Strength pai (0,2%)	Elongation % in 2"	Reduction of Area %	Rockwell Hardness "C"	True Fracture Scress poi
975	361700	292600	6.0	20.0	60.9	430500
1000	351600	292600	8.0	33,4	59.9	453500
1025	345800	292400	7.0	34.1	59.5	440200
1050	344400	277700	7.8	31.2	58.6	435200
1075	321800	280200	6.5	31.0	57.3	398500
1100	305200	266500	6.5	28.5	56.1	378700
1150	253400	215500	7.0	25,2	50.4	311200
1200	200900	158500	9,0	33.0	40.9	259200
1 100	1.44000	105400	14.0	AN A	11.5	226700

Toble 2 - TYPICAL TENSILE PROPERTIES AT 350 km T.S. (Bar heat treated to 350000 pai tensile strength)

(821 most themitte to 330000 por 1	
Tegaile strength, poi	350000
Yield streagth, psi (0.2%)	290000
Elongation, % in 2"	8
Reduction of area, %	33
Rockwell hardness	C60

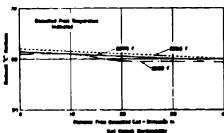
Table 3 - TYPICAL AUSFORMED PROPERTIES*
(Austenite deformed 91% at 1100°F before conventional
quenching and tempering)

Tempering Temperature	Tensile Scrength pai	Yield Strength pai (0,2%)	Elongation % in 2"	Reduction of Area
700	465000	425000	7	22
800	460000	425000	7	25
1000	455000	410000	7	33
1100	435000	390000	9	39
	• From	Justusson and	Zackay	

	I COMPAC		
Rockwell Hardness	Izod Unnot ched ft. lbs.	Charpy Unnotched ft. lbs.	Charpy V-Notch ft. ibs.
57.5	120 + (stops beam)	264 + (stops beam)	13
59.0	120 + (stops beam)	264 + (stops beam)	12
61.0	120 + (stops beam)	264 + (stops beam)	8

Toble 5 - TYPICAL ANNEALED PROPERTIES Tensile strength, poi 95000 Yield strength, psi (0,2%) Elongation, % in 2" Reduction of sres, % 48000 25

B89-93 Rockwell hardness



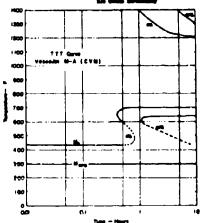


Table 6 - 1 A HGL F PROPERTES No. of Uveles Sucas, par 210 000 COM

\$12,000 768,000 1,167,000 7,157,000 144) ()()() 150,000 Stopped at 106,000,000 Table: - FFFECT OF TEST RESPURGITIRE ON THE TESSILE PROPERTIES Cstandard 0.505" round lensile specimens austenitized in salt at 205091 for 5 minutes, salt quenched at 105091, and triple tempered (2)2)2 hours) as indicated.

Average of two tests per condition.)					
Testing Lemperature	Fempering Temperature op	Yield Strength psi (0,2%)	Tensile Strength (PS)	Reduction of Area	Elongation
500	1000	249200	117400	17.8	6.3
600	1000	255200	108600	37.2	5.H
800	1000	241600	292900	28.7	5.4
9(0)	0001	221400	178600	30.9	5.9
1000	1000	204300	259000	24.9	5.4
500	1075	245000	289200	40.5	6.0
600	1075	229700	280500	11.7	6.3
800	1075	233500	264200	40.5	6.1
900	1075	206200	251300	38.2	5.7
1000	1075	183000	230100	28.8	6.3

Heat Treatment:

Anneal: Heat to 1600-1650 deg, F, cool slower than 50 deg, F per hour to 1000 deg. F, then more rapidly to mom tempo ature.

hardening: Preheat at 1550 deg. F. raise temperature rapidly to 2025-2050 deg. F in a protective atmosphere, hold 5-10 minutes at temperature, quench in air, salt, or oil, temper at 950-1150 deg. F. Double or triple tempering is recommended (2 * 2 * 2 hours).

(Phase changes: The steel transforms on slow cooling from austenite to apheroidite. A1-1380 to 1430°F.

Martensite start temperature, Ms, is 4300F)

Stress Relief: Heat at 875-950°F for 2-4 hours; for finished heat treated parts after grinding, machining or straightening. Machinability:

Rough machining is generally performed on material in the fully annealed condition in much the same manner as any 0.50%C alloy sreel.

Single point turning tools of high speed steel should be ground to 8-12° side rake, 6-10° back rake, 7-10° side relief, 7-10° end relief, 8-15° end cutting-edge angle, 12-18° side cuttingedge angle and a nose radius equal to 10% of cut depth. Sintered carbide-tipped tools should be ground to 4-12° side rake, 2-5° back rake, 5-10° side relief, 5-10° end relief, 8-12° end cutting-edge angle, 10-160 side cutting-edge angle and a 1/32" nose radius.

Use sulphurized or chlorinated oils containing sulphur as lubricants with high speed steel cutters,

Workability:

Forging: Start at 1950 to 1900°F and finish at 1650°F. It organg: Start at 1950 to 19100° and finish at 1650°F, lit should be reheated as often as necessary to prevent forging too cold. Because of its air-hardening properties, it is very necessary that this steel be cooled slowly after forging to prevent the formation of stress cracks. After forging, the material may be returned to a hot furnace and couled slowly with the furnace, or may be buried in some insulating material such as lime, mica or silocel,

Forming: This alloy in the fully annealed condition can be readily formed by all common methods. Straightening can be performed either during cooling from austenitizing or during heating for tempering.

Weldability:

Preheat at 500-10000F, weld with inert gas shielded are or reneal at 200-1000-r, weld with their gas shielded are or coated electrodes; maintain temperature above 600°F, cool slowly in furnace or insulating medium. Welded parts have shown excellent weldability with weld metal strength and ductility equal to or greater than the parent metal. Because of its hardenability, welding requires preheating and post-heating and generally is followed by an anneal.

Welded parts are usually slowly cooled to 200°F, followed by immediate tempering to 1250-1400°F, for softening, to permit final straightening and sizing without cracking.

Corresion Resistance

General corrosion resistance of this steel is low and surface protection is required. For room temperature applications, conventional paint, plating, vapor deposition, and other coatings may be used. For elevated temperature applications, aluminum silicone paint, nickel-cadmium diffusion plating, nickel-zinc plate, etc. may be used.

plate, etc. may be used. Hydrogen embrittlement may occur after hydrogenating treat-ment of the high strength conditions at high strength levels. Hydrogen embiritlement may occur after hydrogenating treat-ment of the high strength conditions at high strength levels. Approved plating methods should be followed by baking at temperatures ranging from 375°F for 23 hours (for low heat resistant plate) to 950°F for heat resisting plate. At the upper end of the operating temperature range, protection is required if slight oxidation to a tight scale is not permissible.

Pickling:

Heat treated parts should be cleaned by mechanical methods. Pickling or cathodic cleaning are not permissible.

General Characteristics:

Vascojet M-A (CVM) is a consumable vacuum arc melted, high strength alloy steel providing more ductility and a smaller differential between longitudinal and transverse mechanical properties. It can be air, salt or oil hardened depending on the section thickness. Triple tempering produces stress relief combined with maximum hardness because tempering is done in the secondary hardening temperature range, i.e., the tange in which the steel develops a higher hardness than at a lower temperature; hydrogen, which can cause embrittlement when tensile strength exceeds 200,000 psi, is rapidly removed and strength is not lowered; retained austenite is transformed, reducing the danger of subsequent transformation to martensite with accompanying high stresses during service. Vascojet M-A (CVM) is a consumable vacuum arc melted, high with accompanying high stresses during service.

Vascojet M-A (CVM) is a high-strength structural steel offer-Vascojet M-A (CVM) is a high-strength structural steel offering tensile strength values up to 360,000 psi at room temperature and high strength levels at operating temperatures to 1000°F. It is readily machined and can be formed by all standard methods of fabrication. In order to achieve maximum strength and ductility, it is recommended that this alloy be ordered in the CVM (consumable vacuum melted) grade. Experience indicates that CVM melting, with subsequent removal of dissolved gases and reduction of inclusions to a minimum, improves transverse type properties by factors of two or three to one. This alloy assures outstanding fatigue strength due to the fact that it offers the full advantage of secondary hardening phenomena.

This steel is highly magnetic, but becomes nonmagnetic at temperatures above 1400 to $1500^{\rm o}{\rm F}$. The damping capacity is 1.3×10^{-4} logarithmic decrement.

Vascojet M-A has been found to respond quite satisfactorily to the ausforming process. Tensile strength levels in excess of 450,000 psi with quite respectable ductility are possible. The deformation of metastable austenite before quenching and tempering enhances strength and hardness.

Forms Available:

Billets, forgings, sheet, plate, bars and wire.

Applications:

Fasteners, airframes, rocket motor cases, high speed rotors, lightweight axles, gears, shafting, pressure vessels, helicopter totors, engine mounts, turbine components, and nuclear applications.

Manufacturer:

Vanadium Alloys Steel Corp. Latrobe, Pennsylvania

Best Available Copy

SPECIMEN NUMBER: 1A	DATE:1/4/73	
TEST CONDITIONS		
Specimen Description		
Material: 2024-T851	Hole spacing (in.):	1-1/8
Material gage (in.): 0.375	Nominal hole size (in.):_	3/8
Size (L x W) (in): 15 x 1.5	Edge margin:	0.7 5 in.
Numer of holes: 12	_	
Coldwork Information		,
Coldwork process: Sleeve		
Mandrel taper (in./in.):0.045		
Mandrel diameter (in.): 0.3537		
Expansion (in.): 0.0185		
RESULTING DATA	0.0017	
Edge bulge at holes, average (in.): Edge bulge between holes, average (in.):		
^a Bow after coldwork (in.):	+0.025	
Bow after ream and countersink (in.):	+0.0085	
bEdge distortion after coldwork (in.):	None	
^C Specimen growth after coldwork (in.): _		
Specimen growth after ream (in.):	0.0085 in 12.375	
Specimen growth after countersink (in.)	0.0080 in 12,375	
^a Bow direction	Direction of coldwork	
(+) Indicates	bow as shown in sketch	

bEdge distortion

(-) Indicates bow in opposite direction

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

SPECIMEN NUMBER: 2A	DATE: 1/4/73
TEST CONDITIONS	
Specimen Description 2024-T851	Hole spacing (in.): 1-1/2 Nominal hole size (in.): 3/8 Edge margin: 0.75 in.
Coldwork information Coldwork process. Mandrel taper (in./in.): Mandrel diameter (in.): Expansion (in.): 0.045 0.3537 0.0185	
RESULTING DATA	
	+0.025 +0.018 None 0.0090 in 12 0.011 in 12
^a Bow direction	Direction of coldwork
	oow as shown in sketch bow in opposite direction
^b Edge distortion	
Value indicate	es amount of side bow

^CMoasurements takes after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

		, WARGIN	DATE: 1/4/7	
SPECIMEN NUMBER:	<u> </u>		DATE:	
TEST COMPLETIONS				
TEST CONDITIONS				
Specimen Description				
Material:	2024-T851		Hole spacing (in.):	1-1/8
Material gage (in.):	0.375	_	Nominal hole size (in.):	3/8
Size (L x W)(in.):	15 x 1-1/8		Edge margin:	0.563 in.
Numer of holes:	12	_		
Coldwork Information				
Coldwork process: _	Sleeve			
Mandrel taper (in./ir	0.045			
Mandrel diameter (ii				
Expansion (in.):	0.0185		=	
RESULTING DATA				
Edge bulge at holes,		0.0020		
Edge bulge between	holes, average (in.):			
^a Bow after coldwork		+0.055		
^a Bow after ream and		+0.045		
^b Edge distortion afte		0.003	10.075	
^C Specimen growth af		0.0165 in 0.0150 in		
Specimen growth af	ter ream (in.): ter countersink (in.):			
Specimen growth at	ter countersink (in.);	, 0,0130 iii	12.070	
^a Bow direction			Direction of culdwork	
			•	
				
	(+) Indicates		n in sketch site direction	
		now in obbo	are duection	
^b Edge distortion	1			
F				
				j
				ŀ
<u> </u>		, 		

Value indicates amount of side bow

 $^{\rm C}$ Measurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance

SPECIMEN NUMBER: 4A		DATE:1/4/73	
TEST CONDITIONS			
Specimen Description			
Material: 2024-T851		Hole spacing (in.):	1-1/2
Material gage (in.): 0.375	_	Nominal hole size (in.):	3/8
Size (L x W)(in.): 15 x 1-1/8	_	Edge margin:	0.563 in.
Numer of holes: 9			
Coldwork Information			
Coldwork process: Sleeve			
Mandrel taper (in., in.): 0.045			
Mandrel diameter (in.):0.3537			
Expansion (in.):			
RESULTING DATA			
Edge bulge at holes, average (in.):	0.0022		
Edge bulge between holes, average (in.):	0.0005		
^a Bow after coldwork (in.):	+0.051		
^a Bow after ream and countersink (in.).	+0.040		
bEdge distortion after coldwork (in.):	0.010_		
^C Specimen growth after coldwork (in.):			
Specimen growth after ream (in.):	0.0150 in		
Specimen growth after countersink (in.):	0.0145 in	12	
⁸ Bow direction		Direction of coldwork	
			.==
			
	bow as shown bow in oppos		
^b Edge distortion			
1			}
}			}
			

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance

PHASE I--TASK 4A-EDGE MARGIN AND HOLE SPACING DATA SPECIMEN NUMBER: 7A DATE: 1/4/73

TEST CONDITIONS

Specimen Description

Material:	2024-T851			
Material gage (in.):				
	15 x 2-1/4			
Numer of holes:	6			

Hole spacing (in.): 2-1/4

Nominal hole size (in.): 3/4

Edge margin: 1.125 in.

Coldwork Information

Coldwork process:	Sleeve	_
Mandrel taper (in, in.): _	0.045	
Mandrel diameter (in.):	0.7145	
Expansion (in.):	0.030	

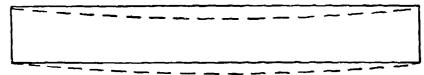
RESULTING DATA

Edge bulge at holes, average (in.):	0.0035
Edge bulge between holes, average (in.):	0.0015
^a Bow after coldwork (in.):	
^a Bow after ream and countersink (in.):	+0.006
bEdge distortion after coldwork (in.).	None
^C Specimen growth after coldwork (in.):	
Specimen growth after ream (in.):	
Specimen growth after countersink (in):	

^a Bow direction	Direction of coldwork

(+) Indicates bow as shown in sketchi-) Indicates bow in opposite direction

^bEdge distortion



^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance

PHASE I-TASK 4A-EDGE MARGIN AND HOLE SPACING DATA DATE: ___1/4/73 SPECIMEN NUMBER: __ TEST CONDITIONS Specimen Description 3,00 2024-T851 Hole spacing (in.): _ Material: ___ 3/4 0.750 Nominal hole size (in.): Material gage (in.):. 1.125 in. 15 x 2·1/4 Edge margin: ____ Size (L x W)(in.) Numer of holes: _ Coldwork Information Sleeve Coldwork process: _ 0.045 Mandrel taper (in.-in.). _ 0.7142 Mandrel diameter (in.): _ 0.030 Expansion (in.): __ RESULTING DATA 0.004 Edge bulge at holes, average (in.): _ Edge bulge between holes, average (in.): None +0.008 ^aBow after coldwork (in.): _____ +0.008 ^dBow after ream and countersink (in.):___ bEdge distortion after coldwork (in.): ___ None ^cSpecimen growth after coldwork (in.): ____0.0095 in 9 0.0115 in 9 Specimen growth after ream (in.): _____ Specimen growth after countersink (in.): 0.0120 in 9 Baw direction Direction of coldwork (+) indicates bow as shown in sketch (-) Indicates bow in opposite direction

Value indicates amount of side bow

^bErige distortion

^c Measurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

PHASE I TASK 4AEDGE !	MARGIN AND HOLE SPACING DATA
SPECIMEN NUMBER: 9A	DATE: 1/4/73
TEST CONDITIONS	
Specimen Description	
Material: 2024-T851	. Hole spacing (in.): 2-1/4
Material gage (in.): 0.750	Nominal hole size (in.): 3/4
Size (L x W)(in.): 15 x 3	Edge margin: 1,50 in.
Numer of holes:6	
Coldwork Information	
Coldwork process: Sleeve	
Mandrel taper (in./in.): 0.045	
Mandrel diameter (in.): 0.7142	
Expansion (in.): 0.030	
RESULTING DATA	
	0.003
Edge bulge between holes, average (in.): _0	
	0.006
. Bott ditte fount one obstiteration (inter-	-0.004 None
	0.0063 in 11,25
	0,0065 in 11,25
Specimen growth after countersink (in.):	
⁸ Bow direction	Direction of coldwork
<u> </u>	
	w as shown in sketch w in opposite direction
^b Edge distortion	
FEE	
Value indicates	amount of side bow

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

SPECIMEN NUMBER: 10A	DATE:	/73
TEST CONDITIONS		
Specimen Description		
Material: 2024-T851	Hole spacing (in.):	3.00
Material gage (in.): 0.750	Nominal hole size (ir	3/4
Size (L x W)(in.): 15 x 3	Edge margin:	1.0
Numer of holes: 4	_	
Coldwork Information		
Coldwork process: Sleeve		
Mandrel taper (in./in.): 0.045		
Mandrel diameter (in.): 0,7142		
Expansion (in.): 0.030		
RESULTING DATA		
Edge bulge at holes, average (in.):	0.0025	
Edge bulge between holes, average (in.):		
^a Bow after coldwork (in.):	+0.006	
^a Bow after ream and countersink (in.):	+0.004	
bEdge distortion after coldwork (in.):	None 0.0045 in 9	
Specimen growth after coldwork (in.):	0.0036 in 9	
Specimen growth after ream (in.): Specimen growth after countersink (in.):		
^a Bow direction	1	
Bow direction	Direction of coldwor	·ĸ
	bow as shown in sketch bow in opposite direction	,
^b Edge distortion		
Value indical	tes amount of side bow	

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

SPECIMEN NUMBER: 1T		DATE:1/6/73	
TEST CONDITIONS			
Specimen Description			
Material: Ti-6AI-4V	_	Hole spacing (in.):	1-1/8
Material gage (in.): 0,375	_	Nominal hole size (in.):	3/8
Size (L x W)(in.): 15 x 1.5	<u>-</u>	Edge margin:	0.75 in.
Numer of holes: 12	_ _	• • -	
Coldwork Information			
Coldwork process: Sleave			
Mandrel taper (in./in.): 0.045			
Mandrel diameter (in.):0.3537			
Expansion (in.): 0.018			
RESULTING DATA			
Edge bulge at holes, average (in.):	0.0015		
Edge bulge between holes, average (in.):	0.0010		
^a Bow after coldwork (in.):	+0.035		
aBow after ream and countersink (in.):	0.001		
DEdge distortion after coldwork (in.): CSpecimen growth after coldwork (in.):	0.001 0.016 in 1	2 375	
Specimen growth after ream (in.):	0.018 in 1		
Specimen growth after countersink (in.):			
^a Bow direction		Direction of coldwork	
(+) Indicates t (-) Indicates t			
bEdge distortion			
Value indicate	es amount of	side bow	

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance

SPECIMEN NUMBER: 2T	DATE: 1/8/73	_
TEST CONDITIONS		
Specimen Description		
Material: Ti-6AI-4V	Hole spacing (in.): 1.5	
Material gage (in.): 0.375 Size (L x W)(in.): 15 x 1.5	Hommal note size (iii.).	
Numer of holes: 9	Edge margin: U.75 in.	
Coldwork Information		
Coldwork process. Sleeve		
Mandrel taper (in .in.); 0.045		
Mandrel diameter (in.): 0.3537		
Expansion (in.): 0.018		
RESULTING DATA		
Edge bulge at holes, average (in.): 0.	0010	
Edge bulge between holes, average (in.): 0.	0005	
	0.017	
Bow after ream and countersink (in.):		
· · · · · · · · · · · · · · · · ·	002	
^C Specimen growth after coldwork (in.). 0.		
Specimen growth after reum (in.):0. Specimen growth after countersink (in.):0.		
Specifier growth after countersink (iii.).	<u> </u>	
^a Bow direction	Direction of coldwork	
	▼	
(+) Indicates bow	as shown in sketch	
(-) Indicates bow	in opposite direction	
bEdge distortion		
Value indicates a	mount of side bow	

^cMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

TEST CONDITIONS Specimen Description	DATE:	
Specimen Description		
Opecimen Description		
T: CAL 41/		
Material: Ti-6AI-4V	Hole spacing (in.):	1-1/8
Material gage (in.): 0.375	Nominal hole size (in.): _	
Size (L x W)(in.): 15 x 1-1/8 Numer of poles: 12	Edge margin:	0.563 in.
Numer of notes: 12		
Coldwork Information		
Coldwork process: Sleeve	_	
Mandrel tapor (in./in.): 0.045	_	
Mandrel diameter (in.): 0.3537	-	
Expansion (in.): 0.018	- -	
RESULTING DATA		
Edge bulge at holes, average (in.): 0.0032		
Edge bulge hetween holes, average (in.): 0.0010		
^a Bow after coldwork (in.): +0.042		
^a Bow after ream and countersink (in.): +0.016		
Edge distortion after coldwork (in.): 0.001		
CSpecimen growth after coldwork (in.). 0.0145 ii		
•	12.375	
Specimen growth after countersink (in.): <u>0.0130 ir</u>	1.12.3/5	
^a Sow direction	Direction of coldwork	
	·	
	un in sketch	
(+) Indicates bow as show		
(+) Indicates bow as show (-) Indicates bow in oppo		
(-) Indicates bow in oppo		
(-) Indicates bow in oppo		==1
(-) Indicates bow in oppo		==]

Value indicates amount of side bow

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance

PHASE 1-- TASK 4A-EDGE MARGIN AND HOLE SPACING DATA DATE: ___1/8/73 SPECIMEN NUMBER: 4T TEST CONDITIONS Specimen Description Ti-6AI-4V Hole spacing (in.):_ Material: _ 3/8 0.375 Nominal hole size (in.):_ Material gage (in.): 0.563 in. 15 x 1-1/8 Edge margin: _ Size (L x W)(in.) : Numer of holes: . 9 Coldwork Information Sleeve Coldwork process: _ 0.045 Mandrel taper (in./in.): __ 0.3537 Mandrel diameter (in.): _ 0.018 Expansion (in.): _ RESULTING DATA 0.0024 Edge bulge at holes, average (in.): Edge bulge between holes, average (in.): 0.0005 +0.055 ^aBow after coldwork (in.): ___ +0.028 Bow after ream and countersink (in.): 0,003 bEdge distortion after coldwork (in.):_ 0.0145 in 12 ^CSpecimen growth after coldwork (in.):_ 0.0160 in 12 Specimen growth after ream (in.): _ Specimen growth after countersink (in.): 0.0155 in 12 ^aBow direction Direction of coldwork

^bEdge distortion

(+) Indicates bow as shown in sketch (-) Indicates bow in opposite direction

⁶Measurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

SPECIMEN NUMBER: 7T	DATE:1/8/73	3
TEST CONDITIONS		
Specimen Description		
Material:Ti-6AI-4V	Hole spacing (in.):	2-1/4
Material gage (in.): 0,75	Nominal hole size (in.):	3/4
Size (L x W)(in.): 15 x 2-1/4	Edge margin:	
Numer of holes: 6		
Coldwork Information		
Coldwork process:Sleeve		
Mandrel taper (in./in.): 0.045		
Mandrel diameter (in.): 0.714		
Expansion (in.):		
RESULTING DATA		
Edge bulge at holes, average (in.): 0.003		
Edge bulge between holes, average (in.): 0.001		
^a Bow after coldwork (in.): +0.003		
^a Bow after ream and countersink (in.):		
bEdge distortion after coldwork (in.): None		
	in 11.25	
Specimen growth after ream (in.): 0.0120	in 11.25	
Specimen growth after countersink (in.): 0.0115	in 11.25	
^a Bow direction	Direction of coldwork	
(+) Indicates bow as sh (-) Indicates bow in o		
^b Edge distortion		

Value indicates amount of side bow

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

SPECIMEN NUMBER: 8T	DATE:1/8/73	
TEST CONDITIONS		
Specimen Description		
Material:Ti-6AI-4V	Hole spacing (in.):	_3
Material gage (in.): <u>0.75</u>	Nominal hole size (in.):_	
Size (L x W)(in.): 15 x 2-1/4	Edge margin:	_1·1/8 in
Numer of holes:4		
Coldwork Information		
Coldwork process: Sleeve		
Mandrel taper (m./in.): 0.045	,	
Mandrel diameter (in.): 0.714		
Expansion (in.): 0.029	-	
RESULTING DATA		
Edge bulge at holes, average (in.): 0,003		
Edge bulge between holes, average (in.): 0.0005		
Bow after coldwork (in.): +0.017		
^a Bow after ream and countersink (in.): +0.011		
bEdge distortion after coldwork (in.): None Specimen growth after coldwork (in.): 0.006 in 9		
Specimen growth after ream (in.):0.006 in 9		
Specimen growth after countersink (in.): 0.006 in 9		
^a Bow direction	Direction of coldwork	
(+) Indicates bow as show (-) Indicates bow in oppo		
bEdge distortion		
Malaining		

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

SPECIMEN NUMBER: 9T	DATE:1/8/73	
TEST CONDITIONS		
Specimen Description		
Material:	Hole spacing (in.):	2.1/4
Material gage (in.): <u>0.75</u>	Nominal nole size (in.): _	3/4
Size (L x W)(in): 15 x 3	Edge margin:	1.50 in.
Numer of holes:6		
Coldwork Information		
Coldwork process: Sleeve		
Mandrel taper (in./in.): 0.045		
Mandrel diameter (in.):		
Expansion (in.):		
Edge bulge at holes, average (in.): 0.00 Edge bulge between holes, average (in.): 0.00 aBow after coldwork (in.): +0.0 aBow after ream and countersink (in.): +0.0	010 012	
bEdge distortion after coldwork (in.): Non		
	085 in 11.25	
opening grant and a second training	075 in 11.25	
Specimen growth after countersink (in.): 0.00	075 in 11.25	
	-	
^a Bow direction	Direction of coldwork	
		 -
(+) indicates bow a		
(-) Indicates bow ii	n opposite direction	

^bEdge distortion

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

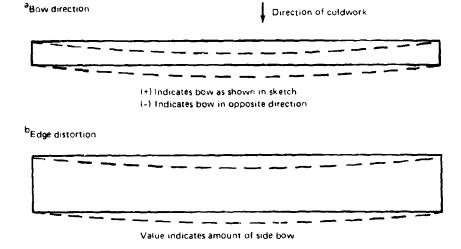
SPECIMEN NUMBER: 10T		DATE:1/8/73	
TEST CONDITIONS			
Specimen Description			
Material: Ti-6Al-4V		Hole spacing (in.):	3
Material gage (in.): 0.75	_	Nominal hole size (in.):	
Size (L x W)(in.): 15 x 3	_	Edge margin:	
Numer of holes: 4			
Coldwork Information			
Coldwork process: Sleeve			
Mandrel taper (in., in.): 0.045			
Mandrel diameter (in.): 0.714			
Expansion (in.):			
RESULTING DATA			
Edge bulge at holes, average (in.):	0.0025		
Edge bulge between holes, average (in.):	0.0010		
^a Bow after coldwork (in.):	None		
^a Bow after ream and countersink (in.):			
bEdge distortion after coldwork (in.):			
^C Specimen growth after coldwork (in.):	0.0030 in 9	9	
Specimen growth after ream (in.):	0.0020 in 9	9	
Specimen growth after countersink (in.):	: <u>0,0020 in 9</u>	9	
^a Bow direction		Direction of coldwork	
		Direction of coldwork	
(+) Indicates	bow as shown	in sketch	
	bow in oppos		
^b Edge distortion			
F			
			-
·			ł
Value indical	tes amount of	side bow	

 $^{\rm C}$ Measurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance

SPECIMEN NUMBER:	18		DATE: _	6/1/73	
TEST CONDITIONS Specimen Description					
Material:	300 M steel		Hole spacing (in	n.):	_1.50
Material gage (in.):	0.375		Nominal hole si		3/8
Size (L x W)(in.):			Edge margin: _	–	9/16 in.
Numer of holes: _	9		, , –		
Coldwork Information					
Coldwork process:	Push, no sleeve				
Mandrel taper (in.,					
Mandrel diameter			•		
Expansion (in.):			-		
RESULTING DATA					
Edge bulge betwee ^a Bow after coldwor ^a Bow after ream an ^b Edge distortion aft ^c Specimen growth a Specimen growth a	s, average (in.): In holes, average (in.): k (in.): d countersink (in.): ter coldwork (in.): after coldwork (in.): after ream (in.): after countersink (in.)	0.103 0.101 0.013 0.032 in 1 0.032 in 1	5 (no change) 5 (no change)		
"Bow direction	n		Direction of co	ldwork	
-					
		s bow as show s bow in oppo			
^b Edge distorti	on				
F					. = = η

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

SPECIMEN NUMBER: 28	DATE: 6/14/73	
TEST CONDITIONS		
Specimen Description		
Material: 300 M steel	Hole spacing (in.): 1.129	<u>}</u>
Material gage (in.): 3/8	Nominal hole size (in.): 3/8	
Size (L x W) (in.): 15 x 1.125	Edge margin:9/16	in.
Numer of holes: 12	_	
Coldwork Information		
Coldwork process: Push, no sleeve		
Mandrel taper (inin.):0.045		
Mandrel diameter (in.): 0.3580		
Expansion (in.):		
RESULTING DATA		
Edge bulge at holes, average (in.):	0.0030	
Edge bulge between holes, average (in.):		
^a Bow after coldwork (in.):	+0.102	
^a Bow after ream and countersink (in.):	+0.102	
Edge distortion after coldwork (in.):	None	
Specimen growth after coldwork (in.):	0.030 in 15	
Specimen growth after ream (in.):	0.030 in 15 (no change)	
Specimen growth after countersink (in.):	0.030 in 15 (no change)	



^cMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

26	DATE: 6/14/73
SPECIMEN NUMBER: 3S	DATE:
TEST CONDITIONS Specimen Description Material: 300 M steel Material gage (in.): 3/8 Size (L x Wi (in.): 15 x 1.50 Numer of noles: 12	Hole spacing (in.): 1.125 Nominal nole size (in.): 3/8 Edge margin: 0.750 in.
Coldwork Information Coldwork process: Push no sleeve Mandrel taper (inin.): 0.045 Mandrel diameter (in.): 0.358 Expansion (in.): 0.023	
Edge bulge at holes, average (in): Edge bulge between holes, average (in.): Bow after coldwork (in.): Bow after ream and countersink (in.): bEdge distortion after coldwork (in.): CSpecimen growth after coldwork (in.): Specimen growth after ream (in.): Specimen growth after countersink (in.):	0.0525 0.0520 None 0.025 in 15 0.025 in 15 (no change)
^a Baw direction	Direction of coldwork
	bow as shown in sketch bow in opposite direction
^b Edge distortion	

 $^{^{\}rm C}$ Measurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance

SPECIMEN NUMBER: 4S		DATE: _	5/30/73	
TEST CONDITIONS				
Specimen Description				
Material: 300 M steel		lole spacing (in		1.50
Material gage (in.): 0.375	_	lominal hole si	—	0.375 0.75 in.
Size (L x W)(in.): 15 x 1.50 Numer of holes: 9	^E	dge margin: _		0.75 111.
Numer of holes:	_			
Coldwork Information				
Coldwork process: Push, no sleeve				
Mandrel taper (in., in.): 0.045	*-			
Mandrel diameter (in.): 0.358				
Expansion (in.): 0.023				
RESULTING DATA				
	0.0015			
Edge bulge at holes, average (in.):	0.0015			
^a Bow after coldwork (in.):	0.064			
^a Bow after ream and countersink (in.):				
bEdge distortion after coldwork (in.):	0.005			
^C Specimen growth after coldwork (in.):	0.018 in 15			
Specimen growth after ream (in.):		•		
Specimen growth after countersink (in.):	0.018 to 15	no change)		
^a Bow direction	1	Direction of co	ldwork	
	1			
	bow as shown in bow in opposite			
^b Edge distortion				
				i
Value indicat	tes amount of sid	de bow		

 $^{^{\}rm C}$ Measurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

PHASE I-TASK 4A-EDGE MARGIN	AND HOLE SPACING DA	ATA
SPECIMEN NUMBER:7S	DATE7/5/73_	
TEST CONDITIONS		
Specimen Description		
Material: 300 M steel	Hole spacing (in.):	2.25
Material gage (in.): 0.75	Nominal hole size (in.): _	3/4 1-½ in.
Size (L x W) (in.): 15 x 3 Numer of holes: 6	Edge margin:	1 · /2 III.
Notice of Holes.		
Coldwork Information		
Coldwork process: Push, no sleeve		
Mandrel taper (in./in.): 0.045 Mandrel diameter (in.): 0.7225		
Expansion (in.): 0.030	•	
RESULTING DATA		
Edge bulge at holes, average (in.):0.0025 Edge bulge between holes, average (in.):0.0007		
^a Bow after coldwork (in.): 10.013		
^a Bow after ream and countersink (in.): +0.013		
bEdge distortion after coldwork (in.): None		
^C Specimen growth after coldwork (in.):0014 in 1		
Specimen growth after ream (in.):No change		
Specimen growth after countersink (in.): No change	<u> </u>	
	•	
^a Bow direction	Direction of coldwork	
(+) Indicates bow as show (-) Indicates bow in oppo		
() Molester Barrin appe		
^b Edge distortion		
		1
<u> </u>		
Value indicates amount o	f side bow	

^eMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

157

SPECIMEN NUMBER: 85	DATE: 7/5/73	
TEST CONDITIONS		
Specimen Description		
Material:300 M steel	Hole spacing (in.):	3
Material gage (in.): 0.75	Nominal hole size (in.):	3/4
Size (L × W)(in.): 15 x 3	Edge margin:	1-1/2 in.
	cage margin.	
Numer of holes:		
Coldwork Information		
Coldwork process: Push, no sleeve	· 	
Mandrel taper (in./in.): 0.045		
Mandrel diameter (in.): 0.7225	- 	
Expansion (in.): 0.030	_	
	_	
RESULTING DATA		
Edge bulge at holes, average (in.): 0.0025		
Edge bulge between holes, average (in.): None-		
^a Bow after coldwork (in.): +0.010		
^a Bow after ream and countersink (in.): +0.010		
^b Edge distortion after coldwork (in.): None		
^C Specimen growth after coldwork (in.):0.010 in	15	
Specimen growth after ream (in.): No chan		
Specimen growth after countersink (in.): No chan	e e e e e e e e e e e e e e e e e e e	
⁸ Bow direction	Direction of caldwork	
(+) Indicates bow as sho (-) Indicates bow in opi		
bEdge distortion		
}		}
		ĺ

 $^{\rm C}$ Measurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance

SPECIMEN NUMBER: 9 S	DATE: 7/5/73	
TEST CONDITIONS		
Specimen Description		
Material: 300 M steel	Hole spacing (in.): 2.25	
Material gage (in.): 0.75	Nominal hole size (in.):	
Size (L x W)(in.): 15 x 2.25	Edge margin: 1-1,	in,
Numer of holes: 6		
Coldwork Information		
Coldwork process: Push, no sleeve	_	
Mandrel taper (in./in.): 0.045	- 	
Mandrel diameter (in.):0.7225		
Expansion (in.): 0.030		
RESULTING DATA		
Edge bulge at holes, average (in.): 0.00		
Edge bulge between holes, average (in.): 0.00		
^a Bow after coldwork (in.):		
^a Bow after ream and countersink (in.): 0.03		
bEdge distortion after coldwork (in.): 0.00		
Specimen growth after coldwork (in.): 0.01 Specimen growth after ream (in.): No c	hance	
Specimen growth after countersink (in.): No c		
⁸ Buw direction	Direction of coldwork	
(+) It dicates bow as		
t-1 indicates bow in	opposite direction	
bEdge distortion		
		=
		-
		1
i		1
4		1

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

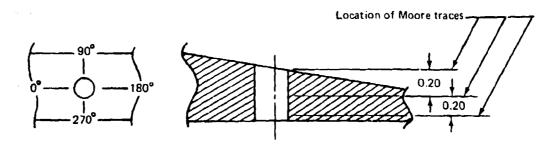
PHASE I-TASK 4A-EDGE MARGIN AND HOLE SPACING DATA DATE: _7/5/73 SPECIMEN NUMBER: __10_S_ TEST CONDITIONS Specime Description 3.00 300 M steel Material: __ Hole spacing (in.): _ 3/4 0.75 Material gage (in.): Nominal hole size (in.):. 1-1/8 in. 15 x 2.25 Size (L x W)(in.): Edge margin: ____ Numer of holes: _ Coldwork Information Coldwork process: Push, no sle ve Mandrel taper (in. in.): 0.045 Mandrel diameter (in.): _ 0.035 & 0.046 Expansion (in.): ____ RESULTING DATA 0.004 (.035 interf.) & .0055 (.046 interf.) Edge bulge at holes, average (in.): None (both cases) Edge bulge between holes, average (in.): 0.026 aBow after coldwork (91.):___ ^aBow after ream and countersink (in.): 0.026 ^bEdge distortion after coldwork (in.): __ None Specimen growth after coldwork (in.): __ 0.011 in 15 No change Specimen growth after ream (in.):_ Specimen growth after countersink (in): No change ^aBow direction Direction of coldwork (+) Indicates bow as shown in skatch (-) Indicates bow in opposite direction ^bEdge distortion Value indicates amount of side bow

^CMeasurements taken after each operation indicated. Some of the difference may be contributed to reamer wander and temperature variance.

PHASE I-TASK 4B-MATERIAL TAPER EFFECT

Material -	Taper (deg)	Centerline shift (in.)	Direction of shift
2024-T851 (AI)	2	0.0035	Top of hole moved as illustrated in all cases Direction of shift
2024-T851 (AI)	4	0.0035	
Ti-6AI-4V	2	0.002	
Ti-6AI-4V	4	0.003	

PHASE I -TASK 4B-SPECIMEN S5, 300M STEEL 2° TAPER

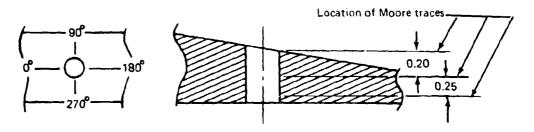


Before coldworking: Center of top of hole, 0.0025 in. toward 180° and 0.0015 in. toward 90°

After coldworking; Center of top of hole, 0.0010 in. toward 180° and 0.0025 in. toward 90°

Conclusion: Center of top of hole moved 0.0008 in. toward 180° (down slope)

SPECIMEN S6, 300M STEEL, 4° TAPER

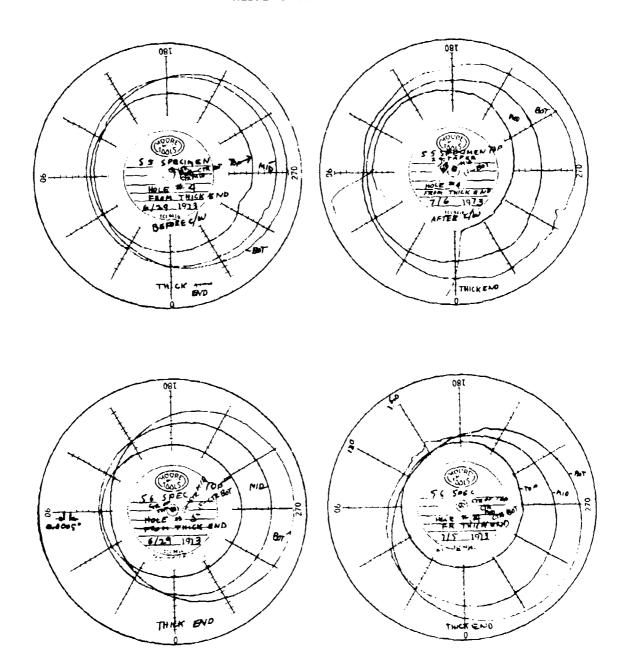


Before coldworking: Center of top of hole 0.0025 in. toward 90° from center of bottom of hole

After coldworking: Center of top of hole 0.0025 in. toward 150° from center of bottom of hole

Conclusion: Center of top of hole moved approximately 0.0017 in. toward 180° (down slope)

PHASE I -- TASK 4B:-MOORE TRACE DATA FOR 300M STEEL; CENTERLINE SHIFT AS A RESULT OF SURFACE TAPER



PHASE I-TASK 4C-LUBRICANT VARIATION

DATE: 1/23/73

MATERIAL: 2024-T851(AI)

MANDREL TAPER (in./in.): 0.045

MATERIAL THICKNESS (in.): 0.375

COLDWORK PROCESS : Sleeve

NOMINAL HOLE SIZE (in.): 3/8

					_	_					- 7					1					
	Remarks	Standard sleeve presently used in production						Loud snapping (chatter) occurred	throughout test; pickup on mandrel.			Pickup from air dried LLC 36	removed from mandrel.				Sleeve lubed inside and mandrel	lubed after insertion in plate.			
	Pull force (1b)	945	1000	1005	965	975	1500	1500	1535	1415	1405	1490	1420	1380	1510	1505	1560	1470	1420	1410	1400
	Sleeve lubricant	Fel Pro 300	Fel Pro 300	Fel Pro 300	Fel Pro 300	Fel Pro 300	LLC 36 air dried	LLC 36 air dried	LLC 36 air dried	LLC 36 air dried	LLC 36 air dried	LLC 36 baked	LLC 36 baked	LLC36 baked	LLC 36 baked	LLC 36 baked	Moly Kote-G paste	Moly Kote-G paste	Moly Kote-G paste	Moly Kote G paste	Moly Kote-G paste
NOMINAL HOLE SIZE III. 1.	Maximum expansion	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	6.0150	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130
NOMINAL	Hole no.	14	A2	A3	AA	A5	A6	A7	A8	18	R2	B3	84	B2	98	87	88	5	3	ខ	2

PHASE I-TASK 4C-SLEEVE LUBRICANT TESTS

(Boeing and Program Data)

	0.015-in.	taper	1,400							15,440	15,430	21,400	15,400	17,200	22,200	22,700	17,500	19,200	17,300	18,000
	<u></u> -	raper						12,000	1	10,830	11,800									
Average force (Ib)	0.025-in.	taper								9,870	12,660									
Average 1	0.030-in.	taper	1,250					7,500												
	0.034·in.	taper								8,880	10,600									
	0.045-in.	taper	965		1,470	1,460	1,450	6,500												
	Material		2024-T851						-	7075-T651										-
	Hole	expansion	0.013					0.025		_										•
	Material	(in.)	3/8					1.1/8		7			-			-				-
:	Hole	(in.)	3/8				-	3/4		_										+
	Mandrel	wipe	Dry			-	Moly Kote-G paste	Dry			Ethyl	Dry		Ethy!	-	Dry		Ethyl alcohol		Dry
	icen:	Additive	1		1	-	1	1				Dacosanol	Johnson 150	wax draw	Eicosanot	-	Stearyl	-	Cetyl alcohol (hot coat)	-
	Sleeve lubricen:	Basic +	Fel Pro 300	(properly mixed)	LLC 36 air dried	LLC 36 baked	Moly Kote-G paste	Fel Pro 300	(properly mixed)	_										+

PHASE I-TASK 4C-SLEEVE LUBRICANT TESTS

(Boeing and Program Data)

							_				—			-7	·			
	0.015-in.	taper	27,100	24,500	15,610		13,000	13,420	16,080	13,540	17,560	17,580	18,860	17,800	22,160	22,260	15,100	15,080
	0.020-in.	taper	15,760 2 (11,800 low) (20,500 high)	12,930		14,300	11,740					_						
rce (lb)	0.025-in.	taper																
Average force (lb)	0.030-in.	taper																
	0.034-in.	taper																
	0.045-in.	taper																
	Material		7075-T651															4
•	Hole	expansion	0.025															•
	Material thickness	(in.)	2															•
	Hole	(in.)	3/4															•
	Mandrei	wipe	Dry	Ethyl alcohol	Cetyl alcohol paste	Wet Fel Pro 300	Dry	·Ethyl alcohol		Dry		Ethyl alcohol		Dry		Ethyl alœhol		Dry
:	Sleeve lutricant	Additive	ł	1	I	1	Paraffin		Cetyl alcohol (hot coat)	-	Cetyl aiobhol (paste coat)		My istal alcohol	-	Dodecyl		Stear! afcohol	-
	Sleeve	Basic +	Fel Pro 300															

PHASE I-TASK 4C-SLEEVE LUBRICANT TESTS (Boeing and Program Data)

									Average force (Ib)	force (lb)		
									JAC: age			1 200
Sleeve lubricant	cant	Mandrel	Hole diameter	Material	Hole	Material	0.045-in.	0.034-in.	0.030-in. taper	0.025-in. taper	0.020-in. taper	0.015-in. taper
Basic	Additive	wipe	(in.)	(in.)			348					Mandrel
		Ethyl	3/4	2	0.025	7075-T651						seized
(improperly mixed)	oil	alcoho!	+			+						20,460
	Johnson 700	-										20,00
	wax draw											3,4
	+	Dry										Mandrel
	Johnson 122	Ethyl										pazias
	wax cut	alcohoi										Seized
	LPS-1	Dry										Seized
	LPS-2											Seized
	LPS-3			-	+	+					19,600	
	Castor				_							
	wax		-	1	+	-					18,400	24,100
	Carnauba											
-	wax		_	1	+	+						Seized
Parattin												16,050
Cetyl alcohol	1	-		_	_							
(paste coat)			+	+	 	-						27,500
	-	Ethyl alcohol		+	-	-						12,040
Fel Pro 300	Heat dried	Dry	-	-	+	-						
(property thised)					İ							

PHASE I-TASK 4D-SLEEVE GEOMETRY

DATE: 1/30/73

MATERIAL: 2024 T851 (AI) MANDREL TAPER (IN./IN.):

(AI) MANDREL TAPER (IN./IN.): 0.045
MAXIMUM EXPANSION (IN.): 0.019

MATERIAL THICKNESS (IN.): 0.75

Remarks			(e)			Helically wound sleeves are easier to remove than standard or scarf edge	sleeves. Profile shows less upset at exit. There is less diametrical difference	between top, middle, and exit of hole.	
Pull force (15)	2280	1980	2000	2030	2160	2180	2120	2125	1950
Retained expansion (in.)	0.0105	0.0110	0.0100	0.0105	0.0105	0.0105	0.0115	0.0110	0.0105
Sleeve type	Standard	Standard	30°scarf edge	30°scarf edge	Helical wound	Helical wound	Helical wound	Helical wound	Helical wound
Hole no.	-	2	3	4	5	9	7	8	6

^aAdditional tests were conducted in aluminum (2024-T851) and Ti-6Al-4V comparing removal characteristics of 30° scarf split sleeves with standard sleeves. These tests showed that there was no appreciable difference between the two. Close examination of the scarf indicated that it was not uniform.

PHASE I-TASK 4E-DIAMETER CREEP

DATE: 2/6/73

MAXIMUM EXPANSION (IN.): 0.018-0.020 NOMINAL HOLE SIZE (IN.): 3/8 MANDREL TAPER (IN./IN.): 0.045 : REAM, COLDWORK, REAM PROCESS

MATERIAL THICKNESS (IN.): _____0.075

Material		Hole size (in.)	
tested	Immediately after ream	One hour after ream	24 hours after ream
2024-T851 (AI)	0.3753/0.3754	0.3752/0.3753	0.3752/0.3753
Ti-6AI-4V	0.3753/0.3754	0.3752/0.3753	0.3752/0.3753

PHASE I-TASK 4F-MANDREL FINISH VARIATION

DATE: 2/7/73

MATERIAL:	2024-T851 (AI)
MATERIAL THICKNESS (IN.):	0.75
NOMINAL HOLE SIZE (IN.):	3/8
MAXIMUM EXPANSION (IN.):	0.018-0.020
MANDREL TAPER (IN./IN.):	0.045
COLDWORK PROCESS:	Sleeve

Hole no.	Mandrel finish	Force (lb)
1	None	2800
2	None	2840
3	None	2800
4	None	2600
5	Vapor blast + Fel Pro 300	3000
6		2580
7		2400
8		2500
9		2480
10		2470
11		2780
12		2540

PHASE I-TASK 4F-MANDREL FINISH VARIATION

DATE:	2/7/73
MATERIAL:	Ti-6AI-4V
MATERIAL THICKN	ESS (IN.) <u>0.75</u>
NOMINAL HOLE SIZ	E (IN.) 3/8
	ION (IN.)_0.018-0.020
	IN./IN.) 0.045
	SS: Sleeve
COLDINARY PROCE	

Hole no.	Mandrel finish	Force (lb)
1	None	3740
2	None	3860
3	None	3700
4	Vapor blast + Fel Pro 300	3560
5		3470
6		3600
7		3680
8	1	3650

PHASE I-TASK 5-MULTIMATERIAL STACK PROCESS DATA

SPECIA	SPECIMEN NUMBER:		2	#	TEST NUMBER:		DATE:_	DATE: 12/13/72
MATERIAL COMBINATION	1. 2024-T851	۲,	6A1-4V-Ti	3	2024-T851	TION: 1, 2024-T851 2, 6AI-4V-Ti 3, 2024-T851 MANDREL TYPE:		ST 5300-CBM-12-0-N
MATERIAL GAGE (IN.)	1. 0.250	.2	0.250 2 0.290 3 0.250	ب ا	1	MANDREL TAPER (IN./IN.): 0.045	./IN.):	0.045
NOMINAL HOLE SIZE (IN.)	3/8					MANDREL MAX DIA (IN): 0.3537	i N	0.3537
						SLEEVE THICKNESS (IN.): 0.010	.('N'	0.010
						LUBRICANT (SLEEVE):_		Fel Pro 300 (on sleeve)

Retained diameter Remarks	expansion in transmiss in transmiss in transmiss in transmiss in transmiss in the contract of	CALL	0.0105 Sleeves fairly easy to remove	0.0110 screw driver for removal—rest pulled out with pliers.	0.0110	0.0110	0.0105	0.0105	0.0110	0.0110	0.0110	0.0110
Retained diameter	in aluminum	/mt-/	0.0125	0.0120	0.0130	0.0130	0.0130	0.0135	0.0130	0.0135	0.0135	0.0130
Actual	diameter expansion	7.00.7	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
7	ruii rorce (Ib)		2350	2045	2115	2040	2015	2080	2165	2145	2145	2135
	dwork	ΙĄ	0.3675	0.3675	0.3675	0 3675	0.3675	0.3680	0.3675	0.3680	0.3680	0.3675
eter (in.)	After coldwork	ij	0.3660	0.3665	03860	0.3665	0.3660	0.3660	0.3660	0.3660	0.3660	0.3660
Hole diameter	oldwork	₹	0.3550	0.3555	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545
	Before coldwork	ï	0.3555	0.3555	0.3550	0.3555	0.3555	0.3555	0.3550	0.3550	0.3550	0.355.0
	Hole no.		C.7	80	0.1	D.2	D-3	0.4	D-5	9-0	7.0	89

PHASE: -TASK 5-MULTIMATERIAL STACK PROCESS DATA

1: 2 DATE: 12/13/72	MANDREL TYPE: ST 5300-CBM-12-0-N	MANDREL TAPER (IN./IN.): 0.045	MANDREL MAX DIA (IN.): 0.3537	SLEEVE THICKNESS (IN.): 0.010
SPECIMEN NUMBER: 1V TEST NUMBER: 2	**************************************	1 0.250 2 0.290 3 0.250	3%	
SPEC	MATERIAL COMBINATION	MATERIAL CAGE (IN.)	MATERIAL CASE (III) 2/8	NUMINAL HOLE SIZE (114)

Fet Pro 300 (on sleeve)

LUBRICANT (SLEEVE):

		Hole diameter	eter (in.)		Pull force	Actual	Retained diameter expansion	diameter	Remarks
Hole	Before c	Before coldwork	After coldwork	ldwork	(tb)	noisuedxa lin i	in aluminum (in.)	in titanium (in.)	
	Ē	₹	1	Ā					
Į.	0.3595	0.3600	0.3560	0.3680	1795	0.014	0.0065	0.0080	Sleeves easy to remove with pliers—most free to slide in hole.
A2	0.3595	0.3600	0.3565	0.3630	1595	0.014	0.0070	0.0080	
A3	0.3K 5	3.36AC	0.3765	03980	1495	0.014	0.0070	0.3080	
A.	ð 3595	0.3600	0.36(4)	୦୫୭୭ ୯	1480	0.014	9900.0	0.0080	
AF	C 3535	0.3500	5.3685	0.3682	1615	0.014	0.0070	0800.0	
, Y	36.95	0.3630	0.3670	0.3680	1680	0.014	0.0075	0800:0	
वे वे	0.3595	0.3600	0.3360	0698.3	1850	0.014	0.0065	0600.0	
A 8	0.3595	0.3600	0936.0	0.3680	1780	0.014	0.0065	0.0080	
α: •	0.35%	0 3600	0.3670	0.3680	1765	0.014	0.0075	030000	
62	0.38.95	0 3600	0.3660	0 3685	2060	0.014	0.0065	9.0085	
1									

PHASE I-TASK 5-MULTIMATERIAL STACK PROCESS DATA

3 DATE: 12/13/72	EL TYPE: ST 5300-CBM-12-0-N	MANDREL TAPER (IN./IN.): 0.045	MANDREL MAX DIA (IN.): 0.3537	SLEEVE THICKNESS (IN.): 0.010
	MANDR	MANDE	MANDE	SLEEVE
TEST NUMBER:	2024-T851	3. 0.250		
2	6A1-4V-Ti 3.	0.290		
SPECIMEN NUMBER:	1. 2024-T851 2.	1 0.250 2 0.290	3/8	
SPECIME	MATERIAL COMBINATION: 1, 2024-T851 2, 6AL-4V-Ti 3, 2024-T851 MANDREL TYPE:	MATERIAL GAGE (IN.)	NOMINAL HOLE SIZE (IN.) 3/8	

Fel Pro 300 (on sleeve)

LUBRICANT (SLEEVE):

		Hole diameter (in.	neter (in.)			Actual coldwork	Retained diameter	Retained diameter	
e S	Betore c	Before coldwurk	After co	coldwork	rull force (lb)	diameter expansion	expansion in aluminum	expansion in titanium	Kemarks
	Ţ	Ą	1.1	Ą		(iui)	(:w:)	(in.)	
F1	0.3655	0.3655	0.3680	0 3680	1565	0.008	0.0035	0.0025	Sleeves easy to remove—free to pull out with fingers.
F2	0.3655	0.3355	0.3685	0.3695	1440	800:0	0.0040	0:0030	
F3	0.3655	0.3655	3898.0	0.3695	1350	0.008	0.000.0	0.0030	
F.A	0 3655	o 3655	0.36.05	0638.0	1365	0.008	0.0035	0.0030	
F5	0 3555	0.3655	0.3680	0.3690	1350	0.008	0.0035	0.0025	
6.6	0 3655	0.3655	C.368U	0.3690	1360	0.008	0.0035	0.0025	
53	0.3655	0.3655	ი:3680	0698:0	1350	900:0	0.0036	0.0025	
62	0 3655	0.3655	0.3680	0.3690	1350	900:0	0.0035	0.0025	
63	0.3655	0.3655	03980	0.3690	1360	0.008	0.0035	0.0025	
G4	0 3655	0.3655	0.3685	0.3695	1355	0.008	0.0040	0.0030	

PHASE I-TASK 5-MULTIMATERIAL STACK PROCESS DATA

SPECIN	ECIMEN NUMBER:	20	TEST NUMBER:	4	DATE: 12/13/72
MATERIAL COMBINATION: 1. 6AL4V-TI 2. 2024-T851 3. 6AL4V-TI MANDREL TYPE	1. 6Al-4V-Ti	2 2024-T851 3	6A1-4V-Ti	MANDREL TYPE:	ST 5300-CBM-12-0-N
MATERIAL GAGE (IN.)	1. 0.285	2. 1.00 3.	0.285	MANDREL TAPER (IN./IN.): 0.045	0.045
NOMINAL HOLE SIZE (IN.)	3/8			MANDREL MAX DIA (IN.): 0.3537	0.3537
				SLEEVE THICKNESS (IN.): 0.010	0.010
				LUBRICANT (SLEEVE):	Fel Pro 300

		Hole diameter (in.)	ieter (in.)			Actual coldwork	Retained diameter	Retained diameter	
Total	Refore c	Refore coldwork	After co	coldwork	Pull force (1b)	diameter expansion	expansion in aluminum	expansion in titanium	Remarks
	÷	Ai	Ti	B		(in.)	(in.)	(ID.)	
۲۵	0.3550	0.3550	0.3660	0.3685	3640	0.019	0.0135	0.0110	1. Sleeves fairly easy to remove—4 sleeves required use of screwdriver
8	0.3550	0332:0	0.3665	2.3685	3520	0.019	0.0136	0.0115	for removal—rest pulled out with pliers.
10	0:3550	0352.0	0.3660	03980	3520	0.019	0.0130	0.0110	2. Sleeve thinout accounts for much of the difference in retained
20	0.3550	0.3550	0.3660	0 3685	3560	0.019	0.0135	0.0110	expansion.
<u>0</u> 3	0.3650	03320	0.3. 35	0:3680	3500	0.919	0.0130	0.0115	
20	03850	0.3550	0.3665	0.3680	3380	0.019	0.0130	0.0115	
05	0.385.0	0338:0	0.3665	0.3685	3320	610.0	0.0135	0.0115	
90	0.3550	0.3550	0.3660	0.3685	3320	0.019	0.0135	0.0110	
20	0.355.0	0.3550	0.3660	0.3685	3420	0.019	0.0135	0.0110	
8	0.355	0530	0:3660	0.3685	3560	0.019	0.0135	0.0110	

PHASE 1-TASK 5-MULTIMATERIAL STACK PROCESS DATA

SPECIA	SPECIMEN NUMBER: 20		20	TEST NUMBER: 5		DATE: 12/13/72
MATERIAL COMBINATION: 1. 6ALAV-TI 2. 2024-TB51 3. 6ALAV-TI MANDREL TYPE:	1 GALAV-T	اء.	2024-7851	3. 6A!-4V-Ti	MANDREL TYPE:	ST 5300-CBM-12-0-N
MATERIAL GAGE (IN.)	1 0.285	12	1.00	0.285 2. 1.00 3. 0.285	MANDREL TAPER (IN./IN.): 0.045	0.045
NOMINAL HOLE SIZE (IN.) 3/8	3/8	1			MANDREL MAX DIA (IN.): 0.3537	0.3537
					SLEEVE THICKNESS (IN.): 0.010	0.010

Fel Pro 300 (on sleeve)

LUBRICANT (SLEEVE):

		Hole diameter (in.)	neter (in.)			Actual coldwork	Retained diameter	Retained diameter	
₹ Ş	Before	Before coldwurk	After coldwork	dwork	Pull force (15)	diameter expansion	expansion in aluminum	expansion in titanium	Remarks
	Ti	AI	Ti	¥		(in.)	(iu:)	(in.)	
₹	0.3605	0.3610	0.3670	0.3695	2800	0.013	0.0085	0.0065	Sleeves easy to remove—sleeve
EA.	9098:0	0.3610	0.3670	0.3695	2400	0.013	0.0085	9900:0	the difference in retained expansion.
4	0.3605	0.36.0	0.3675	0.3655	2300	0.013	0.0085	0.0070	
AS	0 3605	0.3610	0.3670	0.3690	2220	0.013	0.800	0.0065	
AS	0 3605	0.3610	0.3670	0.3695	2420	ຍເບດ	0.0085	0.0065	
A7	0.3805	0.3610	0.3670	0.3695	2400	0.013	0.0085	0.0065	
260	0 3805	0.3613	0 36. פ	0.3695	2460	0.013	0.0085	0.0065	
82	0.3606	0.3610	0.3670	0.3695	2440	0.013	0.0085	0.0065	
83	0 3605	0.3610	0.3670	969£ 0	2460	0.013	0.0085	0.0065	
89	0.3605	0.3510	0.3675	0 3695	2460	0.013	0.0085	0.0070	

PHASE I-TASK 5-MULTIMATERIAL STACK PROCESS DATA

SPECIN	SPECIMEN NUMBER:		2	TEST NUMBER: 6	R: 6	DATE: 12/13/72	12/13/72
MATERIAL COMBINATION: 1. 6414V-Ti 2. 2024-T851 3. 6A14V-Ti MANDREL TYPE	1 GALAV-Ti	اً: ۲	2024-T851	3. 6AI-4V-Ti	MANDREL TYPE:	STE	ST 5300-CBM-12-0-N
MATERIAL GAGE (IN.)	1 0.285	~	0.285 2 1.00 3 0.285	3. 0.285	MANDREL TAPER (IN./IN.): 0.045	N./N.): 0.04	9
NOMINAL HOLE SIZE (IN.) 3/8	3/8				MANDREL MAX DIA (IN.): 0.3537	(IN.): 0.35	37
					SLEEVE THICKNESS (IN.): 0.010	(IN.): 0.01	0

LUBRICANT (SLEEVE):

All force riameter (in.) dismeter diameter (in.) dismeter diameter (in.) dismeter diameter (in.) diameter diameter (in.) diameter diameter (in.) diameter diameter (in.) diameter diameter (in.) diameter diameter (in.) diameter diameter (in.) diameter diameter diameter (in.) diameter diameter diameter (in.) diameter diameter diameter (in.) diameter diameter diameter diameter (in.) diameter diameter diameter (in.) diameter diameter diameter (in.) diameter diameter diameter diameter (in.) 0.3695 1827 0.008 0.0036 0.0036 0.0036 0.0036 0.3695 1660 0.008 0.0036 0.0036 0.0036 0.3695 1480 0.008 0.0040 0.0036 0.3695 1480 0.008 0.0036 0.0036 0.3695 1460 0.008 0.0035 0.0025	A Property	3	1 \$	Hole diameter (in)			Actual	Retained	Retained	
(1b) expansion (in.) in aluminum (in.) in titanium (in.) 95 :800 0.008 9.0040 0.0025 95 :800 0.008 0.0040 0.0025 95 1827 0.008 0.0035 0.0025 95 1860 0.008 0.0035 0.0025 95 1660 0.008 0.0040 0.0025 95 1680 0.008 0.0035 0.0025 95 1480 0.008 0.0040 0.0036 95 1460 0.008 0.0035 0.0025 95 1460 0.008 0.0035 0.0025 95 1460 0.008 0.0035 0.0025		-		I		Pul; force	coldwork	diameter	diameter	Bemarks
AI (III.) (IIII.) (III.) (III.) (IIII.) coldwurk Afte		Afte	3	dwork	₽	expansion	in aluminum	in titanium		
0.3695 1800 0.008 9.0040 0.0025 0.3695 1827 0.008 0.0040 0.0025 0.3695 1720 0.006 0.0035 0.0025 0.3695 1660 0.008 0.0040 0.0025 0.3695 1700 0.008 0.0040 0.0025 0.3695 1480 0.008 0.0040 0.0036 0.3695 1480 0.008 0.0040 0.0036 0.3695 1460 0.008 0.0035 0.0025 0.3695 1460 0.0036 0.0035 0.0025	र्भ ह		=		¥		(iii)	(iui)	(III.)	
0.3695 1827 0.006 0.0040 0.0025 0.3695 - 1720 0.006 0.0035 0.0025 0.3695 1860 0.008 0.0035 0.0030 0.3695 1660 0.008 0.0040 0.0025 0.3695 1700 0.008 0.0035 0.0030 0.3695 1480 0.008 0.0040 0.0035 0.3695 1460 0.008 0.0035 0.0025 0.3695 1460 0.008 0.0035 0.0025	0.3555 0.3655 0.3690		0,3690		0.3695	1800	0.008	9.0040	0.0025	Sleeves easy to remove with pliers. Some pulled out with use of fingers.
720 0.006 0.0035 1860 0.008 0.0040 1663 0.008 0.0040 1700 0.008 0.0035 1480 0.008 0.0040 1460 0.008 0.0035 1460 0.008 0.0035	0.3685 7.3655 0.3650		0.3660		0.5885	1820	0.008	0.0040	0.0025	
1860 0.008 0.0035 1660 0.008 0.0040 1700 0.008 0.0035 1480 0.008 0.0040 1460 0.008 0.0035 1460 0.008 0.0035	0.3655 0.3680 0.3680				0.3685	. 1720	0.006	0.0035	0.0025	
1660 0.008 0.0040 1700 0.008 0.0035 1680 0.008 0.0040 1480 0.008 0.0040 1460 0.008 0.0035 1460 0.008 0.0035	9.3655 0.3660 0.3685		0.3685		569€ n	1860	0.008	0.0035	0.0030	
1700 0.008 0.0035 1680 0.008 0.0040 1480 0.008 0.0040 1460 0.008 0.0035 1460 0.008 0.0035	0.3655 0.3680		0.3680		0.3695	1660	0.008	0.0040	0.0025	
1680 0.008 0.0040 1480 0.008 0.0040 1460 0.008 0.0035 1460 0.008 0.0035	6.3885 9.363C 0.3885	0	0.3685		0.3695	1700	0.008	0.0035	0:0030	
1480 0.008 0.0040 1460 0.008 0.0035 1460 0.008 0.0035	0.3655 0.3680	0	0.3680		0.3695	1680	0.008	0.0040	0.0025	
1460 0.008 0.0035 1460 0.008 0.0035	0.3655 0.3655 0.3685	, ,			0.3695	1480	0.008	0.0040	0.0030	
1460 0.008 0.0035	0.33€5 0.3680 0.3680	0	0.3680		0.3695	1460	0.008	0.0035	0.0025	
A	0.3655 0.3660 0.3680	0			0.3695	1460	0.008	0.0035	0.0025	

PHASE I-TASK 5-MULTIMATERIAL PROCESS DATA

TEST OBJECTIVE

To determine size differential in aluminum and titanium stack after final ream operation

TEST CONDITIONS

- a) Material
 - 1) Test plate 1-V consists of 0.0250-in.-thick 2024-T851 plate + 0.250-in.-thick Ti-6Al-4V plate + 0.250-in.- thick 2024-T851 plate (0.75 in. total)
 - 2) Test plate 2-V consists of 0.250-in.-thick Ti-6Al-4V plate + 1.00 min.-thick 2024-T851 plate + 0.250-in.-thick Ti-6Al-4V plate.
- b) Sizing method
 - 1) Reaming (0.3735-in. diameter) using TB1 (freon)

TEST RESULTS

a) Test plate 1-V as-reamed hole diameter in inches

2024·T851	Ti-6AI-4V	2024-T851
0.3737	0.3742	0.3742
0.3738	0.3740	0.3740

b) Test plate 2-V as-reamed hole diameter in inches

Ti-6AI-4V	2024-T851	Ti-6AI-4V
0.3741	0.3741	0.3742
0.3742	0.3742	0.3745

PHASE I-TASK 6-SIZING PARAMETERS

Aluminum (2024-T851) - 3/8-in. nominal diameter hole in 3/8-in.-thick material, 0.019-in. expansion

Test platur hole no.	Maximum diameter at exit	Typical hole size requirement (in.)	Material to be removed diameter difference (in.)	Comments	
D-1	0.370				
D-2	0.369				
D-3	0.370] [!	
D-4	0.370			5 40 1 1	
E8	0.370	0.3730 <mark>0.3740</mark>	0.003 min	Reamed five holes with 0.373 reamer; no sign	
D8	0.369	0.3730 0.007 max of exit	0.3730 0.007 max 0.573	of exit not cleaning up.	
F2	0.371] [
F3	0.369	71			
F4	0.367] [i	
G-1	0.368	ין	l		

Titanium (Ti-6AI-4V) -3/8-in. nominal diameter hole in 3/8-in.-thick material, 0.019-in. expansion

Test Plate VII hole no.	Maximum diameter at exit	Typical hole size requirement (in.)	Material to be removed diameter difference (in.)	Comments	
A1	0.369	1			
B1	0.370	11			
C1	0.370				
D1	0.371			Reamed five holes with	
A2	0.370	0.3730	0.002 min	0,373 diameter reamer;	
B2	0.370	1 (0.5,000 3730 0.006	0.3730 0.005 max	0.37300.3730	all holes cleaned up
C2	0.370				
D2	0.370] [
E2	0.370] []		
F2	0.371] •			
G2	0.370	<i>י</i> ן			

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APPENDIX III

PHASE II DATA

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A. ALUMINUM

#10¹11

Task ! (base metal)	Stress (ksi)	Cycles
1) 2024-T851	30	370,000 510,000 468,000
	25	810,000 15,576,000 NF 1,660,000
	35	239,000 219,000
	40	112,000 143,000
2) 7175-T736	30	8,022,000 8,156,000 10,123,000 NF
Task 2 (open holes)	Stress (ksi)	Cycles
1) 2024-T851	20	39,000
a) Honed holes	30	46,000 47,000
b) Reamed only	30	45,000 47,000 37,000
	25	46,000 52,000
	20	219,000
	35	11,000 10,000 59,000
	40	14.000 15.000
c) C/W and postreamed	25	975,000 366,000 12,700,000 NF
	35	96,000 114,000

		40	35,000 38,000
2)	7175-T736	•	
,	a) Reamed only	30	45,000 56,000 69,000
	b) C/W and postreamed	30	510,000 618,000 692,000
Tasl	3 (ZLT-filled holes)	Stress (ksi)	Cycles
1)	2024-T851 a) Reamed – net-fit Hi-Loks	30	696,000 565,000 127,000 237,000 205,000
		25	404,000 684,000
		35	82,000 79,000
		40	52,000 49,000
	b) C/W and postreamed-net-fit Hi-Loks	30	591,000 950,000 608,000
		25	7,779,000 NF 8,323,000 NF
		35	311,000 387,000
		40	161,000 149,000
	c) Protruding-head Taperlok	30	1,236,000 947,000 6,086,000 2,662,000
		25	10,075,000 NF 1,594,000 10,164,000 NF
		35	328.000 369,000

		40	237,000 156,000
	d) 100°-flush head Taperlok	30	147,000 264,000 196,000
		25	612,000 661,000
2)	7175-T736 a) Reamed – net-fit Hi-Loks	30	359,000 1,007,000 253,000
	b) C/W and postreamed-net-fit Hi-Loks	30	513,000 523,000 293,000
Tasl	k 4 (process/application variations)	Stress (ksi)	Cycles
1)	All 2024-T851		
	a) Open holes 90°-sleeve split	30	382,000 424,000 335,000
	C/W-as-drilled hole	30	261,000 491,000 226,000
	C/W-abusively drilled hole	30	110,000 287,000 93,000
	C/W-no postream	30	431,000 333,000 330,000
	C/W and score one hole	30	300,000 94,000 393,000
	C/W plus 1/64-in. postream	30	235,000 249,000 214,000
	C/W plus 1/32-in. postream	30	283,000 256,000 285,000
	C/W plus 1/16-in. postream	30	312,000 372,000 226,000

Square wire sleeve	30	167,000 339,000 586,000
0.060-inthick material	30	48,000 49,000 65,000
1-1/2D E/M; 5-1/4D hole spacing	30	855,000 203,000 325,000
2D E/M; 5-1/4 SP	30	504,000 535,000 253,000
2-1/2D E/M; 5-1/4 SP	30	756,000 393,000 254,000
2-1/2D E/M; 3D SP	30	339,000 355,000 380,000
2-1/2D E/M; 4D SP	30	300,000 294,000 272,000
ZLT-filled holes (net-fit Hi-loks unless other	erwise noted)	
One hole not C/W	30	855,000 703,000 325,000
C/W-0.002 clearance, Hi-Lok		694,000 366,000 697,000
C/W-0.000 interference, Hi-Lok		120,000 185,000 250,000
C/W-100°-csk, after		1,247,000 950,000 1,186,000
C/W-100°-csk, before *		169,000 508,000 213,000
C/W = 70°-csk, after		290,000 315,000 191,000
C/Wcracked, before		93,000 515,000 625,000
	0.060-inthick material 1-1/2D E/M; 5-1/4D hole spacing 2D E/M; 5-1/4 SP 2-1/2D E/M; 5-1/4 SP 2-1/2D E/M; 3D SP 2-1/2D E/M; 4D SP ZLT~filled holes (net-fit Hi-loks unless other One hole not C/W C/W~0.002 clearance, Hi-Lok C/W~0.000 interference, Hi-Lok C/W~100°-csk, after C/W~100°-csk, before ' C/W~70°-csk, after	0.060-inthick material 30 1-1/2D E/M; 5-1/4D hole spacing 30 2D E/M; 5-1/4 SP 30 2-1/2D E/M; 5-1/4 SP 30 2-1/2D E/M; 3D SP 30 2-1/2D E/M; 4D SP 30 2LT-filled holes (net-fit Hi-loks unless otherwise noted) One hole not C/W 30 C/W-0.002 clearance, Hi-Lok C/W-0.000 interference, Hi-Lok C/W-100°-csk, after C/W-100°-csk, before ' C/W-70°-csk, after

c)	ZLT-15-hole coupon, filled holes		
	C/W and postreamed	40	149,850 150,320 135,990
J)	LLT-15-hole coupon, filled holes		
-	C/W and postreamed – one at time	30	265,000 264,000 288,000
	C/W and postreamed-production technique	40	153,000 146,000
		30	273,900
	C/W-no postream-production technique	40	154,600 157,200 165,500
e)	HLT-filled holes		
	C/W-net-fit, 0.010-in. shim	30	580,620 371,350 500,440
	C/W-0.002 clearance, 0.010-in. shim	30	281,720 291,700 355,200
	C/W~0.002 interference, 0.010-in. shim	30	924,180 655,880 900,530
	C/W-net-fit flush-head, 0.010-in. shim	30	508,360* 343,460* 557,400*
	C/W-net fit, no shim	30	294,720 386,990 399,190
	C/W-net fit, no shim, upset removed	30	429,000 674,690 990,370
	Taperlok-0.010-in. shim	30	682,310 741,500 369,400
	Taperlok-flush head, 0.010-in. shim	30	1,422,000* 517,810* 548,000*

^{*}Test specimen design did not produce evaluation of countersink zone, only shank zone properly evaluated

Passed only 0.0	010-in. shim 30	201,290
Reamed only, 0.0	J.O.III. Zittili	151,220
		122,060
C/W~0.060-in. sl	him 30	365,020
		867,530
TITANIUM		
Task 1 (base metal)	Stress (ksi)	Cycles
1) Ti-6Al-4V (ann)	80	4,051,000
1) 11 0.11 11 (4.11.)	**	4,200,000
	85	591,000
	0.0	1,400,000
	95	605,000 1,071,000
	100	188,000
		463,000
2) Ti-6Al-4V (STA)	135	35,000
	115	87,000
		44,000
3) Ti-6Al-4V (STOA)	115	113,000 97,000
		117,000
4) Ti-6Al-6V-2Sn (ann)	115	69,000
		53,000
T. T. (11.20 (0T.1)	116	117,000
5) Ti-6Al-6V-2Sn (STA)	115	103,000 90,000
		60,000
6) Ti-6Al-6V-2Sn (STOA)	115	189,000
		107,000
		148,000
Task 2 (open holes)	Stress (ksi)	Cycles
1) Ti-6Al-4V (ann)		
a) Honed holes	65	41,000
		66,000 58,000
b) Reamed only	60	67,000
-,		

43.000

		65	41,000 39,000
		50	103,000 142,000
		55	420,000 51,000 117,000
	c) C/W and postreamed	60	117,000 116,000
		50	1,576,000 6,865,000
		70	70,000 64,000
		65	88,000 104,000
2.	Ti-6Al-4V (STA)		
-	a) Reamed only	70	26,000 30,000 36,000
	b) C/W and postreamed	70	81,000 83,000 51,000
3)	Ti-6Al-4V (STOA)		
<i>J</i> ,	a) Reamed only	70	30,000 32,000 33,000
	b) C/W and postreamed	70	70 00 38.000 58,000
4)	Ti-6Al-6V-2Sn (ann)		
	a) Reamed only	70	51,000 35,000 28,000
	b) C/W and postreamed	70	50,000 70,000 79,000
5)	Ti-6Al-6V-2Sn (STA)		
	a) Reamed only	70	22,000 23,000 24,000

b) C/W and postreamed	70	76,000 94,000 72,000
6) Ti-6Al-6V-2Sn (STOA) a) Reamed only	70	38,000 38,000 30.000
b) C/W and postreamed	70	67,000 48,000 55,000
7) Ti-6Al-4V (ann) (3/4-indiameter holes) C/W and postreamed	70	86,000 54,000 61,000
Task 3 (ZLT-filled holes	Stress (ksi)	Cycles
1) Ti-6Al-4V (ann) Reamed—net-fit Hi-Loks	70	90,000 83,000 78,000
	75	47,000 52,000
	65	109,000 92,000
	60	246,000 139,000
2) Ti-6Al-4V (STA) Reamed—net-fit Hi-Loks	70	65,000 74,000 82,000
3) Ti-6Al-4V (STOA) Reamed—net-fit Hi-Loks	70	82,000 74,000 69,000
4) Ti-6Al-6V-2Sn (ann) Reamed-net-fit Hi-Loks	70	53,000 43,000 56,000
5) Ti-6Al-6V-2Sn (STA) Reamed—net-fit Hi-Loks	70	54,000 48,000 29.000

6)	Ti-6Al-6V-2Sn (STOA)		
•	Reamed-net-fit Hi-Loks	70	70,000 52,000 51,000
	Ti-6Al-4V (ann)		
	C/W and postreamed with net-fit Hi-Loks	70	1,830,000 347,000 698,000
		65	1,333,000 2,273,000
		75	203,000 199,000
		80	180,000 137,000
7)	Ti-6Al-4V (STA)		
Í	C/W and postreamed with net-fit Hi-Loks	70	509,000 468,000 545,000
			343,000
9)	Ti-6Al-4V (STOA)	70	1 590 000
	C/W and postreamed with net-fit Hi-Loks	70	1,580,000 616,000 146,000
	T' (ALCV 35° (and)		• • • • • • • • • • • • • • • • • • • •
10)	Ti-6Al-6V-2Sn (ann)	70	530,000
	C/W a.:d postreamed with net-fit Hi-loks	, 0	487,000 195,000
11)	Ti-6Al-6V-2Sn (STA)		
,	C/W and postreamed with net-fit Hi-Loks	70	143,000 99,000 110,000
12)	Ti-6Al-6V-2Sn (STOA)		
/	C/W and Postreamed with net-fit Hi-Loks	70	197,000 90,000 147,000
13)	Ti-6Al-4V (ann)		
	a) Protruding-head Taperloks	70	367,000 689,000 5,323,000
		75	3,086,000 10,061,000

	65	7,788,000 NF 7,774,000 NF
	60	300,000 7,602,000 NF
b) Flush-head Taperloks	70	1,146,000 240,000 370,000
	75	372,000 99,000
	65	266,000 563,000
	60	1,092.000 2,602,000
Task 4 (process/application variations)	Stress (ksi)	Cycles
l) (all Ti-6Al-4V (ann)		
a) Open holes		
90°-sleeve split (C/W)	70	179,000 87,000 79,000
C/W as-drilled hole	70	63,000 66,000 66,000
C/W-abusively drilled hole	70	47,000 43,000 54,000
C/W-no postream	70	79,000 88.000 82,000
C/W-score, one hole	70	85.000 72,000 76,000
C/W plus 1/64-in. postream	70	61,000 64,000 64,000
C/W plus 1/32-in. postream	70	54,000 76,000 67,000
C/W plus 1/16-in. postream	70	62.000 67,000 54,000

C/V	V square wire sleeve (no results, see data s	sheet)	
	60-inthick material C/W plus postream	70	61,000 50,000 61,000
	/2D E/M; 5-1/4D hole spacing C/W s postream	70	46,000 90,000 68,000
	E/M: 5-1/4D hole spacing -C/W plus stream	70	49,000 56,000 52,000
	/2D E/M; 5-1/4D hole spacing C/W is postream	70	67,000 63,000 62,000
	1/2D E/M; 3D hole spacing C/W plus estream	70	58,000 81,000 74,000
	1/2D E/M; 4D hole spacing C/W plus ostream	70	59,000 104,000 66,000
b) Filled l	noles (ZLT) -(net-fit Hi-Loks unless others	wise noted)	
	ne hole not C/W	70	119,000 77,000 1,286,000
C	/W=0.002-in. clearance, Hi-Lok	70	153,000 226,000 179,000
C	/W-0.002-in. interference, Hi-lok	70	4,421,000 6,836,000 824,000
	*/W-csk after	70	217,000 212,000 483,000
C	C/W-csk before	70	760,000 757,000 1,064,000
C/W-70	C/W-70°-csk after	70	555,000 570,000 435,000

	C/W-prefatigued	70	709,000 431,000
	C/W-cracked before	70	312,000 92,000 782,000
c)	ZLT-15-hole coupon, filled holes		
	C/W postreamed	70	124,450 122,210 60,780
d)	LLT-15-hole coupon, filled holes		
	C/W and postreamed-production technique	70	40,190 31,840 47,330
	C/W, no postreamed -production technique	70	98,040 187,150 191,330
	C/W, postreamed-2024-T851 stringer plus		
	Ti-6Al-4V (ann) skin	40(Al) 64(Ti)	61,590 79,170 64,620
e)	HLT-filled holes		
	C/W-net-fit, 0.010 shim	70	21,280 22,500 17,340
	C/W-0.002-in. clearance, 0.010-in. shim	70	18,660 20,640 20,000
	C/W-0.002-in. interference, 0.010-in shim	70	24,140 24,700 26,630
	C/W-net-fit, flush head, 0.010-in. shim	70	11,580 6,200 11,170
	C/W-net-fit, no shim	70	30,700 39,950 33,630
	C/W-net-fit-no shim, upset removed	70	98,140 36,180 31,890
	Taperlokprotruding head, 0.010-in. shim	70	73.970 78.490 62,280

Taperlok-flush head, 0.010 shim	70	9,590
Taperiok—Husii head, 0.010 shiin		8,450
·		8,740
Reamed only-net-fit Hi-Lok	70	19,050
Reamed only meeting in box		18,060
		10.940

C. 300M STEEL (27C/300 KSI)

Task I (ba	se metal)	Stress (ksi)	Cycles
		110	10,000,000 NF 10,000,000 NF
		120	10,000,000 NF
		130	591,000 177,000 2,558,000
		135	364,000
		140	84,000 114,000
Task 2 (o	pen holes)	Stress (ksi)	Cycles
a)	Honed holes	105	43,000 34,000 42,000
b)	Reamed only	100	113,000 400,000
		105	139,000 103,000 75,000
		110	48,000 60,000
		115	32,000 49,000
c)	C/W and postreamed	100	99,000 132,000
		105	54,000 72,000 71,000
		110	41,000 62,000

		115	127,000 46,000
d)	C/W and postreamed 3/4-indiameter holes	100	100,000 75,000 210,000
Task 3 (2	ZLT-filled holes)	Stress (ksi)	Cycles
a)	Reamed only plus net-fit Hi-Loks	100	112,000 237,000
		105	97,000 136,000
		110	76,000 90,000 62,000
		115	40,000 51,000
b)	C/W and postreamed with net-fit Hi-Loks		
·	(0.045 in./in. mandrels taper)	100	673.000 8,300,000
		105	462.000 4,203,000
		110	141.000 382,000 252,000
c)	C/V and postream with net fit Hi-Loks		
•,	(0.030 in./in. mandrel taper)	110	390,000 349,000 264,000
d)	C/W and postream with netfit Hi-Loks (0.045 in./in. mandrel taper) (0.005 in.		204,000
	less interference)	110	121,000 118,000 105,000
e)	C/W and postream with net fit Hi-Loks (0.015 in./in. mandrel taper)	110	287,000 364,000 76,000
Task 4 (1	process/application variations)	Stress (ksi)	Cycles
a)	Open holes		
	0°-sleeve process	110	93,000 280,000 178,000

90°-split sleeve process	110	163,000 128,000 114,000
C/W -no postream	110	428.000 388,000 208,000
C/W-score, one hole	110	103,000 67,000 110,000
C/W -as-drilled hole	110	266,000 152,000 252,000
C/W- abusively drilled holes	110	113,000 150.000 380,000
C/W plus 1/64-in, postream	110	6 5 ,000 45,000 59,000
C/W plus 1/32-in. postream	110	248,000 121,000 209,000
C/W plus 1/16-in. postream	110	58,000 72,000 55,000
0.060-inthick material	110	71,000 12,000 47,000
1-1/2D E/M; 5-1/4D hole spacing	110	100,000 170,000 177,000
2D E/M; 5-1/4D hole spacing	110	78,000 44,000* 56,000*
2-1/2D E/M; 5-14D hole spacing	110	70,000 72,000 182,000
2-1/2D E/M; 3D hole spacing	110	91,000 80,000 116,000

^{*}Grip failed

	2-1/2D E/M; 4D hole spacing	110	120,000 145,000 143,000
b)	ZLT -filled holes (net-fit Hi-Loks unless otherwise	e noted)	
	One hole, not C/W	110	43,000 52,000 33,000
	C/W -0.002-in. clearance, Hi-Lok	110	711,000 254,000 283,000
	C/W -0.002-in, interference, Hi-Lok	110	3,282,000 198,000 244,000
	C/W-100°-csk after	110	9,993,000 NF 7,760,000 NF 1,510,000
	C/W -70°-csk after	110	935,000 420,000 2,547,000
	C/W-100°-csk before	110	38,000 26,000 36,000
	C/W-prefatigued	110	343,000 7,508,000 NF
	C/W-cracked before	110	7,484,000 NF 486,000
c)	HLT-filled holes (Hi-Loks)		
	C/W-net-fit, 0.020-in. shim	110	18.830 17,240 13,750
	C/W=0.002-in. clearance-fit, 0.020-in. shim	110	14,850 21,820 17,150
	C/W-0.002-in. interference fit, 0.020-in. shim	110	20.350 15.040 21.930
	C/W—net fit, flush head, 0.020-in shim, side plates reduced to 0.125 in. thick	110	7,919 8,090 9,300

	Stress	Cycles	Stress*	Cycles
Reamed only 0.020-in, shim	110	4,220	110	4,220
Realifed Only 0.020 in still	95	8,040	110	2,500
	95	9,320	110	3,000
C/W-net fit, no shim	122	7,150	110	10,000
C/W-net in, no sinn	122	9,660	110	15,000
	122	11,770	110	20,000

TEST NUMBER:	II Base
NOMINAL EXPANSION	N VALUE:
GENERAL TEST CONDITIONS	DATE: 1-15-73
1 Specimen Description	3. CW Process
Zero load transfer Configuration: Fig. 2 Width: 1.50" Hale spacing: - Edge margin: - Material: 2024 T 851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: Nane	Sleeve type: Axial Split Sleeve thickness: Sleeve orientation CW Mandrol P
2. Hole Preparation	4. Fatigue Conditions
Nominal hale size: Process: 2024 Base Metal 30 ksi	Net stress: 30 ksl Test lood: 10,500 lbs Load ratio: (R) = 0, 1 Test Frequency: 5000/mInute Test Laboratory: Materials Test Engineer: D. Reesa Test Machine: Vibrophore (36 Kir

o. R623077	No.		le Diame (inches)	ter		ie Fin (RHR)	ish	CW Expansion es)	Fed Expansion (3)	Failure ands)	Origin of Failure		
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Retained Diometrical Exp (Inches)	Cycles to Foilure (Thousands)	and Remarks		
-1									-	370			
-2				" o	40,	ا ر 3 ج ا	, _			510			
-3										468			

Taken at Minimum (midpoint)

TEST NUMBER:	II BASE
NOMINAL EXPANSION	VALUE:
GENERAL TEST CONDITIONS	DATE: 1-15-73
Zero load transfer, Configuration: Fig. 2 Width: 1.50" Hole spacing: - Edge margin: - Material: 2024 T 851	Sleeve type: Axial Split Sleeve thickness: Sleeve orientation CW Mandro CW M AP Apor Dio.:
Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: Nane 2. Hale Preparation Nominal hale size:	Fel Pro 300 (on sleeve. 4. Fatigue Conditions
Process: 2024 Base Metal 25 ksi	Net stress: 25 ks1 Test load: 9,600 lbs Load ratio: (R) = 0.1 Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 Kip)

o. R623077	Z		le Diame (inches)	ter		ole Fin (RHR)	ish	CW Exponsion (8)	red Exponsion es)	· Failure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	er ream	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
-4					 i					810	
-5				W 0	40,	\ E S				15,576 NF	No Failure
-1C	-		_							1,660	

	NOM	NAL EXPANSIOI	VALU	E:
GENER	AL TEST CONDITIC	NS.		DATE: 1-15-73
1. Spe	ecimen Description		3.	CW Process
1	Material gauge: Surface Treatment:	Fig. 2 1.50" 24 T 851 0.250" Shot Peen		Sleeve type: Axial Split Sleeve thickness: Sleeve orientatic CW Mandre' CW M A P Appr Dia.: Fel Pro 300 (on sieeve)
	ole Preparation Nominal hale size: Process: 202 Base N 35 ks	letal	4.	Fatigue Conditions Net stress: 35 ksi Test load: 11,750 lbs Load ratio: (R) = 0.1 Test frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Roese Test Machine: Vibrophore (36 Kip)

o. R623077	Ão.		e Digme	ter	•	le Fin (RHR)	ish	CW Expansion es)	Exponsion	Failure ands)	Origin of Failure
Specimen No.	Hole 1	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual CV Diometrical Ex (Inches)	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
-6										239	
-7				NO _	,, 0,	(& c	, _			219	
			1						-		

[] > Taken of Minimum (midpoint)

				TES	JUN T	MBER:	:	ll Base			
			N	OMINA	L EXP	ANSI	ON V	'ALUE: _	-		
	ENER	AL TEST	COND	TIONS				D	ATE:	1-15-73	
	. Sp	_ Zero lo	Descripti od transf	er				3. CW	/ Process Sleeve	type: _ A	xial Split (E-
		Width: Hole sp Edge mo Materia Materia Surface	oration: ocing: orgin: ol: ol: ol: ol: ol: ol: ol: ol: ol: ol	202 nt: 5	4 T 8:	51			Sleave Sleeve CW Ma CW M	thickness: orientation indreft P	or Dia.:
	2. ⊦	Nomina	paration Il hole si	ze: -	<u>.</u>			4. Fat		ess:	40 ksi 12,500 lbs
		Process	Base	24 Metal ksi				-	Test Fre Test La Test En	itio: (f equency: boratory: gineer:	(2) = 0.1 5000/minute Materials D. Reese Vibrophore (36 Kip)
o. R623077	o,		e Diamei	er .		le Fin (RHR)	iish	CW Expansion es)	Expansion	Failure ands)	Origin of Failure
Specimen No. R623077	Hole No.	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and Remarks
-8										112	
-9				и o	40,	ر 3 - ا	,			143	
	-										
<u> </u>	Tak	en at Mi	nimum (r	nidooint	 -		<u> </u>		لــــــا	· · ·	

	TEST NUMBER:	BASE (7175 T736)
٠.	NOMINAL EXPANSION	VALUE:
<u>GE</u>	NERAL TEST CONDITIONS	DATE: 4-5-73
1.	Specimen Description	3. CW Process
	Zero load transfer Configuration: Fig. 2 Width: 1.50" Hole spacing: - Edge margin: - Material: 7175 T 736 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: None	Sleeve type: Axial Split Sleeve thickness: Sleeve orientatis CW Mandrs' P June Dia.: NO Jujor Dia.: Fel Pro 300 (on sleeve)
2.	Hole Preparation Naminal hole size: Process: 7175 Base Metal	4. Fatigue Conditions Net stress: 30 ksi Test load: 11,250 lbs Load ratio: (R) 0,1 Test frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 Kip)

o. R623077	No.		e Diame inches)	ter	1	le fin (RHR)	ish	I CW I Expansion res)	ned Expansion es)	Cycles to Failure (Thousands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Fail (Thousands)	and Remarks
-1										8,022	
-2				40	40,	(E e				8,156	
-3										10,123 NF	

1 > Token of Minimum (andpoint)

Ti-6Al-4V (annealed) base metal 80 ksi

SPECIMEN 623077 DATE 8/16/73

	ons 	•	30.5	0.1	4000 cpm	Materials	D. Reese	100 kip Vibraphore	
,	FATIGUE CONDITIONS	Max net stress (ks.)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
SPECIMEN 623077 DATE 8/16/73	HOLE PREPARATION	Nominal hole size (in l.	Process	1	ł	FASTENER INSTALLATION	Type	F14	Torque (in Ib)
TEST SPECI	COLDWORK PROCESS	Interference	Sireve type	Sleeve thickness (in.)	Sleeve orientation	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (in)	Lubrication
	SPECIMEN DESCRIPTION	Configuration Fig. 2	Material Ti-6AI-4V (annealed)	Width (:-) 1.50	Hote spacing	Erige margin (in)	Material gage (in) 0.250	Surface treatment Shot DRD	

Origin of failure	and :emarks	}			Failed at radius intersection	}			Failed at radius intersection	_			
Cycles	fariure	4,051,000				4,200,000							
Fastener size (in)	Fit											_	
Fastener	Diameter												
Coldwork expansion (-n)	Retained												
Colc	Actual												
â	After												
Hole finish (RHR)	After												
Ĭ	Before coldwork												
_	After												
Hole diameter (in)	After												
Ī	Sefore cordwork												
	ž 8	-	2	3	4	-	2	3	4	-	2	3	4
S OPE IN	1 02	-				2							

Ti-6Al-4V (annealed)
base metal
85 ksi

PHASE II - TASK 1 - BASE METAL VALUES

	FATIGUE CONDITIONS	Max (ret) 10md (krp)	Load ratio (R)	Test frequency	Materials Test laboratory	Test engineer	100 kip Vibraphore		
623077 DATE 8/16/73	HOLE PREPARATION	Nominal hole size fin !	Process		NCIL	FASTENER INSTALLATION	Type	Fit.	Torave (in 1b)
TEST 172 SPECIMEN 623077	COLDWORK PROCESS	Interference	Sieeve typis	Sieeve thickness (in)	Sleeve Orientation	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (in 1.	
	SPECIMEN DESCRIPTION	Configuration Fig. 2	Material Ti-6AI-4V (anneated)	Width (in)	Hote spacing	Edge margin (in f	Material gage (in).	Surface treatment	

			Ţ					_				_	-		_	_			}
	Origin of failure			}		*		Failed at radius intersection											
	Cycles	failure		591,000					1,400,000									-	
(UI) acts sometre D																		-	1
1000110	an an Carlo	D.ameter													}				
No. K	expansion (in)	1																	
Coldwork	(Su p Clx a		Actua										-		_		-	\ \ -+	
	~	13.14	ream				1					_	+	-	_		-	+	
	Hate finish (RHR)		COLISMOTE																
	Ž.		Belone coldwork				1												
			Afre				1					1							
	Hole diameter in i		After	COSCIMON												1	-		
	<u>0</u>		Before	coldwork												1			
		Hote	ç		-		5	3	4	-	,	,	۳	4	-		~	8	4
		Specimen	£ 8		4					5									

Ti 6At 4V (annealed) base metal 95 ksi

PHASE II-TASK 1- BASE METAL VALUES

TEST_113_ SPECIMEN_623077_DATE_8/16/73

	NS Q5	•	10	4000 cpm	Materials	D Beese	100-k io Vibraphore		
	FATIGUE CONDITIONS	Maxinet stress (kst)	Max test load (kip)	Load ratio (R)	Test frequency	l est laboratory	Test enqineer	Test machine	
SPECIMEN USSULT DATE CONTROL						Z			
	HOLE PREPAHATION	Nominal hole size (iii.)	Process			FASTENER INSTALLATION	Type	Į.	Torque (in. 1b)
ł									
TEST	COLDWORK PROCESS	liiterference	Sleeve type	Siegue Thickness (un.)	Sleeve orientation	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (in)	to the Control of
		Fig. 2	Ti-6Al-4V (annealed	1 50	:	-	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Material	Width In)	Hote spacing	Edge margin In 1	Material gage (m.)	Surface treatment	

						_						7				٦			
Origin of failure	and remarks	}				Failed at radius intersection					School of a direction	railed at loanes market							
Cycles	605,000					1,071,000													
Fastener size lin 1	ž.		 												i				
Fastener	Diameter														-				
lwork ton (in)	Relained																		
Coldwork expansion (in)	Actual										-		 		 				
	Alter												 		 				
Hole finish (RHR)	After													Ļ <u> </u>					
ĭ	Before			į I															
	After																		
Hole diameter (m.)	After																		
HO	Before																		
	i S		-	~	ا س		4	-	^	.	٣	4	-	2	<u>س</u>	4			
	Specimen dash no	(<u>ب</u>																

100-kip Vibraphore 4000 cpm D. Reese Materials Ti 6Al 4V (annealed), base metal 100 ksi FATIGUE CONDITIONS Max net stress (ksif May test load (kip) Test laboratory Test frequency Load ratio (R) Test engineer Test machine DATE 8/16/73 FASTENER INSTALLATION Nominal hole size (in) HOLE PREPARATION Torque (in .lb) Fit Type PHASE 11 - TASK 1- BASE METAL VALUES Process SPECIMEN 623077 1657 Mandrel max diameter (in.).--Mandrel taper (in /in) Sleeve type Sleeve thickness (in.) COLDWORK PROCESS Steeve orientation Mandret material Lubrication Interference Ti-6Ai-4V (annealed) Shot peen Fig. 2 0.250 1.50 SPECIMEN DESCRIPTION Material gage (in) Surface treatment Edge margin lin ! Configuration Width (in) Hole spacing Material

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			7					,	_		_	_	_		,	_	_		 7	7
Origin of failure and remarks			{				sintersection		}	N	 F)	_	s intersection		_	— Г	 7			
C COPTE								Failed at radius intersection					_	Failed at radius intersection					- - -	
	Cycles	failure		188,000					463.000	2001001		-			-					
100	Fastener size (in)								1			1			+				+	
			:																	
Coldwork	expension (in)	District in																		
Cold	engens	9.150												1	-		-	1		
	â	After	Fear					-	_		+	-		1	_		-	+	-	4
	Hole finish (RHR)	2000	coldwork				}						_							
	Ĭ		COUTWOTE																	
			After																	
	Hole diameter (in)		Atter	CONCINCIA																
	Hole		Before	colchwork				_				_				-			 	-
	Hole		۶	- 1	-	1	, 	<u>س</u>	4		~	~		m	4	1.	-	2	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	4
		Specimen	2		89						6									

100 kip Vibraphore 4000 cpm Materials D. Reese 0.0 Ti-6AI-4V (sta), base metal 135 ksi FATIGUE CONDITIONS Max net stress (ksi) Man test foart (kap) Load ratio (R) Test lationalory Test frequency Test engineer Test machine DATE 8/16/73 FASTENER INSTALLATION Nominal hole size (in.) HOLE PREPARATION Torque (in Ib) Process SPECIMEN 623077 id^1 PHASE II - TASK 1 - BASE METAL VALUES TEST________ Manderl max diameter (m.). Mandrel taper (in /in) Sterve thickness (in.) COLDWORK PHOCESS Skieve onentation Mandred material Lubric stign Interference Sleeve Lybe Shot peen Tr-6AI-4V (sta) 0.250 20 SPECIMEN DESCRIPTION Edge margin lin 1 . Material gage (in) Surface treatment Configuration Hole spacing Width (in) Material

Origin of failure and remarks		(Failed at radius intersection					Failed at radius intersection
Cycles to failure		35,000				87,000					000 88				
size tin)	11.												<u> </u>	: - +	
Fastener size fin)	Diameter			ì											
Coldwork expansion (in)	Hetained													- i	
Cold	Actual											!		-	
=	Altu						<u> </u> 						-	 	
Hole finish (RHR)	After														
F	Before											 			
	Alte											 		 	i
Hole dameter (m.)	Alter	Colitions													
T I	Before	COTCHANDS IN													
	I OF		-	2	3		-	7	,	,	4	-	~		4
	Specimen 1		- Sta			-	cts					ti s			

100-kip Vibraphore 4000 cpm Materials D. Reese 5 Ti 6At 4V (stoa), base metal, 115 ksi FATIGUE CONDITIONS Max net stress (ksi) Max test load (kip) Test laboratory Load ratio (R) Test frequency Test engineer Test machine SPECIMEN 623077 DATE 8/16/73 FASTENER INSTALLATION Nominal hole size (in.) HOLE PREPAHATION Torque (in 1h) Provess Tyth PHASE II - TASK 1- BASE METAL VALUES Ē TEST_ITE Mandrel max diameter (in.) Mandrel taper (in /in) Seeve thickness (in.) COLDWORK PROCESS Sleeve onentation Mandeel material Interference Lubrication Sleeve type Ti-6Al-4V (stoa) [Surface treatment F ig. 2 0 2 5 0 1.50 SPECIMEN DESCRIPTION Material goge (in) Edge margin (in) Configuration Hole spacing Width tin I Material

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5.

Origin of failure	and remarks	}										Out of the second of the secon	ration at radius miles across
Cycles	failure	113,000				97.000				117,000			
l uij azis	F												
Fastener size (in)	Diameter												
Coldwork expansion (in)	Retainert												
Colc	Actual											-	
	Atim											_	
Hole finish (RHR)	Afric		 										
3	Before												
_	After												
Hole dameter (in)	After											İ	
£	Belore												
L	1 of 6	-	2	3	4	-	2	6	4	-	2	ກ	4
	desh or	stoa				2 stoa				stoa			

THE PARTY OF THE P

Ti-6AI-6V2Sn (annealed). base metal, 115 ksi

PHASEII -TASK 1- BASE METAL VALUES

TEST______ SPECIMEN_623077 DATE 9/20/73

δ 7	614		4000 com	Materials	Beer	100 bio Vibraobore		
FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Fit	
							(in)	
COLDWORK PROCESS	Interference	Sleeve type	Sleeve thickness (in.)	Steeve orientation.	Manckel material	Mandrel taper (in./in.)	Mandrel max diameter (in)	
SPECIMEN DESCRIPTION	Configuration Fig. 2	Material Ti-6Al 6V2Sn (annealed)	Width (in)	Hole spacing	Edge margin (in)	Material gage (in)	Surface treatment	

Origin of failure	and remarks				Failed at radius blend	_		A series of the	railed at radius oreits	{			Failed at radius blend
Cycles	fadure	000'69				53,000			90	000'/1			
Fastener size (in)	į.												
Fastener	Diameter												
Coldwork expansion (in)	Retained												
Cold	Actual												_
æ	After												
Hole finish (RHR)	After												
Ĭ	Before coldwork												
	After												
Hole diameter (in)	After												
Hol	Before												
	Foie 5	-	,	~	,,	_	2	3	4	-	2	3	4
	dest dest	1.662				2 662				3 662			

Ti-6AI 6V2Sn (sta), base metal, 115 ksi		Max net stress thss.) Max test load (kip) Load ratio (R) Test frequency Test taboratory Test aboratory Test machine 100-kip Vibraphore	
PHASE II - TASK 1_ BASE METAL VALUES	TEST ITB SPECIMEN 623077 DATE 9/20/73	Interference Sieeve thickness (in) Sieeve chickness (in) Mandrel material Mandrel taber (in /in) Mandrel max diameter (in). Type Type Torque (in /ib)	רוואניזויסט
		SPECIMEN DESCRIPTION Configuration Fig. 2 Configuration Ti-6AI-6V2Sn (sta) Width (in) 1.50 Hole spacing Edge margin (in)	

Origin of failure	and remains				Failed at radius blend				Failed at radius blend				Failed at radius blend	
Cycles	failure	03,000				90,000		-		000'09			-	
Fastener size (in)	ŭ.												-	
Fastener	Diameter		1											
Coldwork expension (in)	Retained													
Cold	Actual													
8	Atter						_		1	-			-	
Hole finish (RHR)	After													
1 	Before	i among												
	After	mean	ļ								 			
Hole diameter (in)	After	coldwork												
HOH	Before	colchwork												
	a o		-	2	3	4	-	2	3	4	-	2	3	4
	Specimen , desth		-1- 662-sta				3. 662-sta				3. 662 sta			

PHASE II-TASK 1- BASE METAL VALUES

Ti 6AI 6V2Sn (stoa), base metal, 115 ksi

		115	44	01	4000 cpm	Materials	D. Reese	100 kip Vibraphore	
	FATIGUE CONDITIONS	Max net stress (ksil	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
20/73						NO			
SPECIMEN 623077 DATE 9/20/73	HOLE PREPARATION	Nominal hole size (in.)	Process			FASTENER INSTALLATION	Type		Torque (m. ib)
TEST 179 SPECIMEN									
TEST	COLDWORK PROCESS	Interlerence	Sleeve type	Sleeve thickness (in.)	Sleeve orientation.	Mandrel material	Mandret taper (in /in.)	Mandrel max diameter (in).	Lubrication
		Fig. 2	Ti-6AI-6V2Sn (stoa)	1.50	1	I	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Material	Width (in)	Hale spacing	Edge margin (in)	Material gage (in.). 0.250	Surface treatment Shot peen	

lanture.	¥ }	}			end	_			end	{			end
Origin of failure	and remarks				Failed at radius blend				Failed at radius blend				Failed at radius blend
Cycles	factore	000'681				102,000				148,000			
Fastener size (in)	Fit												
Fastener	Diameter												
Coldwork expansion (m.)	Retained												
	Actual												
â	Alter												
Hote traish (AMR)	After coldwork				i								
Ĭ	Before coldwork												
Hole diameter (in.)	Alter												
	After												
H _O	Before to dwork												
	ğ g	-	2	3	4	-	2	C	4	_	2	3	4
		1.662 stoa				7 662 stos				3.662 stoa			

· Anderson

PHASE II TASK 1- BASE METAL VALUES

300 M, Base Metal, 110 KSI...

	110 and 135	419 and 50	100	4400 cpm	Materials	200	100-kip Vibraphore	
FATIGUE CONDITIONS	Max and ottens thus	Mar rost loans (kip)	Load ratio (R)	إملا وبمالاتهادة	First above above	آمدا مباراتيموا	Te,: machine	
		-			10.			
HOLE PREPARATION	"destinated frame some feet)	Process			FACTENER INSTALLATION	7.62	ž	Forque to the
			1				1.	1
COLOWORK PROCESS	hotor feering e	Steer will hypie	Steepe the Loess (m.)	Slenyminterntalion	Manuer rateral	Mander taper (in in)	Planded max diameter fin 1.	
NOIL	F.19. 2	300 M steel (270.300 ksi)	1.50	1	I	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Majer 200 A	Watth load	burnett man	Edge margin fin 5	Waterial gage Lin ! 0.250	Surface treatment	

Organ of faiture	and remarks	}			135 Ksi (net stress)	No failure			110 ks (net stress)	No faikure			110 KS (net suess)
24;147	factors	364,000				000,000				000,000		-	
f test of the	Ξ	i											
E astener sure les l	Diametra												
Cartilwork expension for t	Retained												
Cott	Actual												
Ē	After												
Hole frash (RHR)	Alter							ļ					
3	Britare											 	
_	After												
Hole diameter (in l	After												
H	Before												
	I 6	-	2	3	4	S3 ⁻	IOH	ON I	4	-	2	3	4
	Speritoren dask no	7				-2				-3			

PHASE II -TASK 1 - BASE METAL VALUES

300 M, Base Metal, 140 KSI

TEST___18 SPECIMEN 623077 DATE 6/11/73

HOLE PREPARATION

FATIGUE CONDITIONS

SPECIMEN DESCRIPTION

COLUMORK PROCESS

					_		-5				4	7 S	Specimen			Su	ž	m	¥	¥	Ę	8
-	3	2		-	-	10 H	OLE	S	3	2	-	<u> </u>	Hote) 		Sadale treatmont	Material gige In I	Edge margin (in)	Hale specing	Width (in)	neral 3	Configuration .
						-	-				-	Before						2	1,	1.50	OO M steel	1
												After culdwork	Hole (hameter (in)			Shot peen	0.250			8	Material 300 M steel (270-300 ksi)	,
										-	-	After	(m)		-	. Men	. Man	. Nun	, Sheen	Sieev		hater
												Byfare coldwark			Tariff Callery	Mendrel max diameter (in) _	Mandret taper (m nn)	Mandrel material	Sheeve otsentation	Sleeve thickness (i.i.)	Sleeve type	Interference
												After	Hole finish (RHR)	 		eter (m)	<u>.</u>	1	:	- - 	İ	1
	\					ļ			 			Alter	HR)		r		1	1	-	},	-	
												Actual	expant Con		٠,	[{	(FAS	(í	19	2
	}											Hetainird	Coldwork expansion (in)		Torque un thi		Type	TENER INST			Process .	Numinal hole size (in.)
												Diameter	Fastene					FASTENER INSTALLATION				size (in)
												ĩ	Fastener size (in)		•	-	l.				-	
							114,000				84,000	favlure	Cycles				ł				ł	Ì
1]									I	n.	Q.			Test asschine	Test ingineer	Test laboratory	Test frequency	Load ratio (R)	Mux rest load (kip)	Max net stress (ksi)
			\ \ \ \ \	{	_		ر ا				}	and remarks	Origin of failure			100 kip Vibrahore	D. Reese	Materials	4300 con	<u>0.1</u>	52	ŧ

•	E11 .	Type .	FASTENER INSTALLATION			Process	Numinal hole size (in.)
			LATION				(m)
	Test machine	Test counteer	Test laboratory	Test frequency	Load ratio (R)	Max rest load (kip) 52	Max net stress (ksi)
	100 kip Vibrahore	D. Reese	Materials	4300 cpm	0.1	52	140

Ì												-6	no dash	perimen	Specimen Des Configuration Material Width fin 1 How wacms Edge marque Material gap Surface trea	
ļ	∵	~	~	+	NO.	HO	LES	; •	,	ω	2	-	ā			
													Belore	¥	F1(0)N Fig. 2 Fig. 2 A steel (270-30) 1 50 1 0.250 2 Shot peen	
											-		After	Hale diameter (in)	SCRIPTION Fig. 2 on 150 300 M steel (270-300 ksi) 150 150 0250 gr (m) 1 0.250 gr (m) 1 0.250 Shot peen	
-					1								After		COLOWORK PE Steeve type Steeve thicks Steeve thicks Steeve thicks Steeve thicks Mandret taps Mandret taps Mandret ma	PHASE
_					1								Betore	1	COLDWORK PHOCESS Sherve thickness (in) Sherve thickness (in) Sherve thickness (in) Mandret taper (in (in) Mandret taper (in (in) Mandret taper (in (in)	H -TASK
-													After ruidwork	Hole trush (RHR)	<u> </u>	PHASE II -TASK 1 - BASE METAL VALUES
-		İ	1	1	1	+	1	1					After	2	SPECIA	META
-		+-											Actual	uedka	300 M Base Metal 120 No.	NALUS
•													Retained	(u) unisuedad	FASTENER INSTALLATION Type Fit Torque in the the the the the the the the the the	, S
		+-	1	1	1								Diameter	Fastenc	DATE 6/11/73 PARATION I POIR SIZE (IN)	
-	-	+	+		+		1		 	-	+-		Ę	Fastener size (in)		
							-7					1,000,000	langre	Cycles		ļ
	<u>.</u>							7		_		No failure		Origin of failure	FATIGUE CONDITIONS Man net vices (kin) A6.3 Man test fund (kip) Load ratio (R) Test finations Fell laboratory Test machine D. Reese Test machine 100 kip Vi	
)	}			}		_		<u>}</u>			46 3 46 3 Agon cpm Agon cpm D. Reese 100-kip Vib-aphore	

Specimen Cash NO HOLES Before Hole diameter (in.) Aiter After Before coldwork Hale traish (RHR) After Afre Actual Coldwork expansion (in) Retained Fastener size (in) 2,558,000 Cycles 10 lature 177,000 591,000 Origin of failure and remarks

	Material gage (in) U.2.34 Surface treatment Shot peen	Edge margin (in)	Width (in) 1.50	Configuration rig. 2 Configuration 300 M steel (270-300 ksi)	SPECIMEN DESCRIPTION		
Lubrication - Torque (in -tb)	Manutrel max diameter (in) For	FASTENER INSTALLATION Text laboratory		Interference	COLDWORK PROCESS HOLE PREPARATION FATIGUE CONDITIONS 130	TEST 10 SPECIMEN 623077 DATE 6/11/73	PHASEII -TASK 1 - BASE METAL VALUES

NOMINAL EXPANSION	VALUE:
ENERAL TEST CONDITIONS	DATE: 1-30-73
Specimen Description Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 J.851 Material gauge: 0.375" Surface Treatment: Shot Peen Fastener: None	Sleeve type: Axio! B Sleeve thickness CW Mr CW Mr CW A rer: Major Dia.: Major Dia.: Major Dia.: Major Dia.: Major Dia.: Major Dia.:
2. Hole Preparation Nominal hole size: 3/8" Process: Drill, ream, Hone 2024 Honed Open 30 ksi	A. Fatigue Conditions Net stress: 30 ksi 1 Test load: 8,500 lbs. Load ratio: (R) 0,1 Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Rease Test Machine: Vibrophore (36 KIP)

o. R-623078	No.	Hole Diameter (inches)		e Diameter Hole Finish .i		Hole Finish (RHR)		bed Expansion	failure ands)	Origin of Failure	
Specimen No.	Hole			After Hone			After Hone	Actual CV Diametrical Ex (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and Remarks
	1	•		.3755			25	-	-		
-1	2			.3755		_	25	-	-	39	
	1	-	-	.3760	-	-	25	_			
-2	2	-	-	. 3760	-	-	25	_	_	46	
	1	_	_	.3755	-	-	20	-	_		
-3	2	-	-	,3755		_	20	_		47	,

Taken at Minimum (midpoint)

TEST NUMBER:	II A 2
NOMINAL EXPANSION	VALUE:
GENERAL TEST CONDITIONS	DATE: 1-30-73
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0.375" Surface Treatment: Shot Peen Fastener: None	Sleeve type: Axial 'CABLE' Sleeve thickness: Sleeve orier CWMAPPLU-CBMG-N Per: Al Major Dia.:
2. Hole Preparation	4. Fatigue Conditions
Nominal hole size: 3/8" Process: Drill & Ream 2024 Reamed Open 30 ksi	Net stress: 30 ksi Test load: 8,500 lbs. Load ratio: (R) 0.1 Test Frequency: 5,000/minute Test Laboratory: Materials Test Engineer: D, Reese Test Machine: Vibrophore (36 Kip)

. R-623078	ġ	ł	Hole Diameter Hole Finish (inches) (RHR)		nish	CW Expansion	bed Expansion Is)	Failure ands)	Origin of Failure		
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual CW Diametrical Ex (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thausands)	and Remarks
	1	-	<u> </u>	. 3760	-	-	40	-	_		
-5	2	-	-	.3760	_		50		-	45	
	1	-	-	. 3765	-	-	53	_	-		
-6	2	-	-	. 3765	-	-	50	-	-	47	1
	1	-	-	. 3760	-	-	45	-	_		
-7	2	-	-	. 3760	-	-	50	-	-	37	

Taken at Minimum (midpoint)

LIMPE II IMPL	
TEST NUMBER	R: 2A
NOMINAL EXPANS	ION VALUE:
GENERAL TEST CONDITIONS	DATE: 3-9-73
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Canfiguration: Width: 1.50" Hole spacing: Edge margin: Material: Material gauge: Surface Treatment: None	Sleeve type: Sleeve thickne- Sleeve orie CW Mr CW A P per: I Major Dia.:
2. Hole Preparation Nominal hole size: 3/8"	4. Fatigue Conditions Net stress: 20 ksi
Process: Ream	Test load: 5,675 lbs Load ratio: (R) = 0.1
2024 Reamed Open 20 ksi	Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore 36 Kip)

Specimen No. R623078	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Reom	Cycles to Failure (Thousands)	Origin of Failure and Remarks	
-14	1	. 3760			65	59	C/W	
"	2	.3765			65]	35 ksi (Net Stress)	
	1	.3730			30	219		
-21	2	.3736			30	219	C/W	
	1							
-	2							

			Ν			MBER	_		<u>.</u>		
Gi	NER	RAL TEST	T COND					_		1-30-73	3
1.		Zero lo Configu Width: Hale sp Edge ma Materia Materia Surface	Descriptional transforation: pacing: pargin: pal: pal gauge: Treatment:	1. 1. 0. 20 int: Sh	Fig. 3 50" 50" 75" 24 T 8 375"	351			V Process Sleeve Sleeve CW M	type: A thickner orir	. E *
2	F	Nomino	paration of hole si : <u>Drill &</u> Re)	4. Fat	Test lo- Load ro Test Fro Test La Test En	ess: 25 od: 7(otio: (lequency: oboratory: ogineer:	5 ksi DOO lbs. R) - 0. 1 5000/minute ,Materials D. Reese /ibrophore (36 Kip)
	e No.	(Hole Diameter (inches)			Hole Finish (RHR)		val CW cal Expansion nches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	Origin of Failure
3	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Act Diametri	Ret Diametric (In	Cycle: (The	Remarks
	1	-	-	. 3760	-	-	60	_	-		
	2	-	-	. 3760	-	-	55	-		46	
	1	-	-	. 3760	-	_	45	-	-		
[2	-	-	.3760	-	1	55	_	-	52	,
					}						

1 - Taken at Minimum (midp..int)

TEST NUMBER:	II A 4
NOMINAL EXPANSION	VALUE:
GENERAL TEST CONDITIONS	DATE: 1-30-73
Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0.375" Surface Treatment: Shot Pean Fastener: None	Sleeve type: Arise Sleeve thicks CABOO CBM0- Sleeve 1
2. Hale Preparation	4. Fatigue Conditions
Nominal hale size: 3/8" Process: Drill & Ream	Net stress: 35 ksi Test load: 9950 lbs. Load ratio: (R) = 0.1 Test Frequency: 5000/minute
Reamed Open 35 k s l	Test Laboratory: <u>Materials</u> Test Engineer: <u>D. Roese</u> Test Machine: <u>Vibrophore (36 Kip)</u>

. R-673078	No.		Hole Diameter (inches)		(inches) (RHR)				ish	I CW Il Expansion hes)	Expansion es)	Cycles to Failure (Thousands)	Origin of Failure and
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Retained Diametrical Ex (Inches)	Cycles t (Thou	Remarks		
	1	_	_	.3760	-		50	1	-				
-10	2	_	-	.3760	-	-	60			11			
	1	_	_	.3760	-	-	30	_		10			
-11	2		-	.3760	-	-	50						
]											
		·-·											

[] > (aken at tAinimum (midpoint)

TEST NUMBER: 11 A4 (a)

	NOMINAL EXPANS	ION VALUE:
GEN	VERAL TEST CONDITIONS	DATE: 3-9-73
١.	Specimen Description	3. CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: None	Sleeve type: C B Sleeve thicknr C B Sleeve or! C W M P C C A B C B
2.	Nominal hole size: 3/8" Process: Ream 2024 Reamed Open 35 ksi	4. Fatigue Conditions Net stress: 35 ksi Test load: 10,000 lbs Load ratio: (R) = 0.1 Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 Kip

Specimen No. R623078	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fostener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-11A	1	. 3732			25	27	
	2	.3732			-		
-12A	1	.3733			25	28	
	2	. 3733			-]	,,,,
-	1						
	2	1 ! 					

SENERAL TEST CONDITIONS	DATE: 1-30-73
Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0.375" Surface Treatment: Shot Peen Fastener: None	Sleeve type: Axial Sleeve thickness: Sleeve orien CW Mar P JU-CBM- CW AP P P Major Dia.: Tion: Fel Pro 300 (on sleeve)
2. Hale Preparation Nominal hale size: 3/8" Process: Drill & Ream	4. Fatigue Conditions Net stress: 40 ksi Test load: 11,500 lbs. Load ratio: (R) = 0,1 Test Frequency: 5000/minute Test Laboratory: Materials

o. R-623078	No.		le Diame (inches)	tor		Hole Finish (RHR)		CW Exponsion	Expansion	Failure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks
	1	-	-	. 3760	-	-	50	-	-		
-12	2	-	-	. 3760	-	_	100	-	-	14	
	1_	-	_	.3760	-	_	100				
-13	2	-	-	. 3765	-	~	80	-	-	15	
		-									
							<u> </u>	ļ <u> </u>			

[] > Taken at Minimon (midp int)

1EST NUMBER:	11 A 6
nominal expansion	VALUE: 0.0185-0.020
GENERAL TEST CONDITIONS	DAT <u>19-73</u>
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0.250" Surface Treatment: Shot Pean Fastener: None	Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM-12 -0-N CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: 0.354" Lubrication: Fel Pro 300 (on sleeve)
2 Hale Preparation Naminal hale size: 3/8" Process: Drill, ream, CW & ream	4. Fatigue Conditions Net stress: 25 ksi Test load: 7,000 lbs. Load ratio: (R) = 0,1 Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese
C/W Open 25 ksi	Test Machine: Vibrophore (36 Kip)

s. R-623078	ġ	†	e Diame inches)	ter		ole Fir (RHR)	nish	CW Exponsion es)	Exponsion	Foilure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Ex (Inches)	Cycles to Foilure (Thousands)	and Remarks
	1	, 3555	3665	3735	35	20	30	.0185	.0110		
-15	2	. 3552	. 3668	3735		-	-	1 .0188	.0116	975	, c\w
	1	.3552	.3665	3735	35	20	30	0188	.0113		
-16	2	. 3555	.3665	3735	-	<u> </u>	-	.0185	.0110	366	1 C/W
-22	1	.3555	.3670	. 3730	40	20	30	.0185	.0115	12,700	No Failure
-22	2	3555	,3670	. 3730	<u> </u>	<u> -</u>	<u> </u>	0185	.0115	12,700	140 I dililie

^{1 -} Taken at Minimum (midpoint)

CENERAL TEST CONDITIONS	DATE: 2-9-73
1. Specimen Description - Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1,50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0,250" Surface Treatment: Shot Peen Fastener: Nane	Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -(CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: 0.354" Lubrication: Fel Pro 300 (on sleeve
2 Hole Preparation Nominal hole size: 3/8" Process: Drill, ream, CW & ream 2024 C/W Open 35 ksi	4. Fatigue Conditions Net stress: 35 kai Test lood: 9,900 lbs. Load ratio: (R) = 0,1 Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D, Reese Test Machine: Vibrophore (36 Klp)

s. R-623078	1 1		iameter Hole Finish nes) (RHR)			CW Expansion es)	Expansion	Failure ands)	Origin of Failure		
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
	1	.3555	.3665	. 3735	40	20	30	.0185	.0110		
-17	2	.3555	,3665	.3735	-	_		.0185	.0110	96	' C.∕W
	1	.3555	.3665	.3735	35	15	30	.0185	.0110		
-18	2	. 3555	,3665	.3735	-	-	-	.0185	.0110	114	c _/ w
]					

The state of Director and the

	FEST NUMBER:	<u>II A</u>	8
	NOMINAL EXPANSION	VALU	E: 0.0181-0.020
GEN	NERAL TEST CONDITIONS		DATE: 2-9-73
1.	Specimen Description	3.	CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Fig 2 Width: 1,50" Hole spacing: 1,50" Edge margin: 0,75" Material: 2024 T 851 Material gauge: 7,250" Surface Treatment: Shot Pagn Fastener: None		Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -0-N CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: 0.354" Lubrication: Fel Pro 300 (on sleeve)
2.	Nominal hale size: 3/8" Process: Drill, ream, CW & ream 2024 C/W Open 40 ksi	4.	Ret stress: 40 ksi Test load: 11,400 lbs. Load ratio: (R) = 0,1 Test Frequency: 5000/minuta Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 Kip)

s. 8-623078	Š.	Hol (Hole Finish (RHR)			I CW I Exponsion net Exponsion Exponsion es)		Cycles to Failure (Thousands)	Origin of Failure		
Specimen No.	Hole ?	Before CW	Afrer CW	After reom	Before CW	After CW	After Ream	Actual Diametrical (Inche	Retained Diametrical Ex (Inches)	Cycles to (Thous	and Remarks
	1	. 3555	.3665	3735	40	20	30	.0185	.0110		
-19	2	. 3555	. 3665	. 3735	-	_	_	.0185	.0110	35	C/W
	1	.3560	. 3665	.3735	40	20	30_	.0180	.0105	_	
-20	2	, 35 55	3665	. 3735	-	-		.0185	.0110	38	¹ C/W

1 Taken at Minimum (midpoint)

TEST NUMBER:	11 A 9 (7175 T 736)
NOMINAL EXPANSION	N VALUE:

NOMINAL EXPANSION	VALUE.
GENERAL TEST CONDITIONS	DATE: 4-5-73
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1 50" Hole spacing: 1 50" Edge margin: 0,75" Material: 7175 7 736 Material gauge: 0,250 Surface Treatment: Shot Peen Fastener: None	Sleeve type: Axial Sleeve thickness: AB 00 Sleeve orien: CW Mar. CW Mar. CW P P P P P P P P P P P P P P P P P P P
2 Hole Preparation Nominal hole size: 3/8" Process: Ream Only 7175 Reamed Open 30 ksl	A. Fatigue Conditions Net stress: 30 ksi Test lood: 8,500 lbs. Lood ratio: (R) 0,1 Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 Kip)

	. R-673078	Ž		e Diamet	er		e Finis	_	ctual CW trical Expansion (Inches)	ined 1 Expansion hes)	Cycles to Failure (Thousands)	Origin of Failure and
	Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Exp (Inches)	Cycles (Thou	Remarks
+	S	-			.3735	-	-	35				
	-1	2	↑		.3735	-	-				45	
t		1	_	-	. 3735		-	40		<u> </u>	56	
	-2	2	-	-	.373	5 -						
Ì		1	-	1-	373.	5 -	-	35	i	-		
	-3	2	-	1 -	373	34 -	_			1-	69	

> (oken at Miniceme (midge int)

test number: nominal expansioi	<u> </u>
GENERAL TEST CONDITIONS	DATE: 4-15-73
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1,50" Hale spacing: 1,50" Edge margin: 0,75" Material: 7175 T 736 Material gauge: 0,250 Surface Treatment: Shat Pean Fastener: None	Sleeve type: Axial Sn' E Sleeve thickness: Sleeve orientat' CW Mandr' CW M. P C'' A sign Dia.: Fel Pro 300 (on sleeve)
2. Hole Preparation Nominal hole size: 3/8" Process: Ream, C/W, Ream 7175 C/W Open 30 ksi	4. Fatigue Conditions Net stress: 30 ksi Test lood: 8,575 lbs. Load ratio: (R) = 0,1 Test Frequency: 5000/minute Test Laborotory: Materials Test Engineer: D, Reese Test Machine: Vibrophore (36 Kip)

s. R-623078	Ž		e Diame inches)	ter		le Fin (RHR)	ish	CW Expansion	bed Expansion es)	Failure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Ex (Inches)	Cycles to Fail (Thousands)	and Remarks
	1	. 3540	.3670	.3735	3 5	15	40	.0190	.0130		
4	2	.3540	. 3670	, 37 3 5	-		-	. 0190	.0130	510	' c/w
	1	.3540	.3670	.3735	35	15	35	.0190	.0130	(10	1
-5	2	.3540	. 3670	.3735	-	-	-	.0170	.0130	618	
	1	.3540	.3665	.3735	40	15	40	.0190	.0125		
-6	2	.3540	3670	3735		-		.0190	.0130	692	c/w

t - Tal en at Minimum (midphint)

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Tr 6At 5V anneated, honed open, ö5 ksi

rest_2T!

OATE 9/14/73 SPECIMEN 623078

FATIGUE CONDITIONS Max net stress (ksr) Max test load (kip) Test laboratory Load ratio (R) Test frequency Test engineer Orill, ream, hone 3/8 FASTENER INSTALLATION Nominal hole size (in) HOLE PREPARATION Process Mandrel taper (in /in) Sleeve thickness (in.) COLDWORK PHOCESS Sierve or rentation Mandrel material Interference Sleeve Type Tr.Al-4V (annealed)

Fig. 2

Configuration

SPECIMEN DESCRIPTION

1.50

Width (in) Material

0.75 1 50

> Hole space ig fin } Edge margin (in)

36-kip Vibrzphore

Test machine

Torque (in 1b)

Mandret max diameter (iii.)

Shot peen 0.250

> Material gage lin J Surface treatment

Lubrication

4000 cpm Materials D. Reese

of fasture	and remarks	{			{			}	{	7		}	
Orono	pue										4		
Cycles	tailure	41,000	41,000			99'000				28,000			
Fastener size (in)	ı.												
Fastener	Diameter												
Caldwork expansion (in)	Relained												
Coll	Actual												
ā	Alter	30				æ	-			35			
Hole Linish (RHR)	After												
Ĭ	Before coldwork												
_	Alter	0.3755	0 3755			0.3755	0 3755			93750	0.3755		
Hole diameter (in.)	After												
Ę	Before coldwork												
i I		-	2	3	4	-	2	3	4	_	2	3	4
Specimen	gg oc	1.				?				έ			

Ti 6Al 4V, reamed open 60 ksi

\	S	09	18,5	0.1	4000 cpm	Materials	D. Reese	36 kip Vibraphore	
	FATIGUE CONDITIONS	Max net stress (ks.)	Max test load (kip)	Load ratio (R)	Test frequency.	Test laboratory	Test engineer	Test machine	
(30/73		0.375	Ream			NOI			
TEST_272 SPECIMEN_623078 DATE 8/30/73	HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Fa	Torque (in 1b)
272 SPECIMEN.									
TEST	CCLDWORK PHOCESS	Interference	Sleeve 172e	Sleeve (hickness (in.)	Sterve orientation	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (m.).	A STATE OF THE PARTY OF THE PAR
	NOIL	Fig. 2	Ti 6Al 4V (annealed)	1.50	1.50	0.75	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Material .	Width (in)	Hate spacing (in)	Edge margin (in)	Material gage (in). 0.250	Surface treatment	

Orign of failure	and remarks	{				}				{			
Cycles	io failure	000'29	67,000			43,000							
Fastener size (in)	Fit												
Fastener	D:ameter				i								
Coldwork expansion (in)	Retained												
Colo	Actual												
- -	After	25	:			25							
Hale linish (RHR)	After												
Ĭ	Before colchwork												
	After	0.3755	3755			0 3755	0.3755						
Mole diameter (in)	After		i I										
ž	Before cordwork												
	5 5	-	2	3	4	-	2	3	4	_	7	8	4
Specimen	2 0	Þ				ŵ							

- T ₁ 6A/4V. reamed open 64 ksi		FATIGUE CONDITIONS	Max met stress (ks.) 65	Max test load (kip) 19.2	Load ratio (R) 0.1	Test frequency 4000 cpm	Test taboratory Materials	Test engineer D. Reese	Test machine 36 kip Vibraphore	
OLE VALUES	623078 DATE 8/30/73	HOLE PREPARATION	Nominal hole size (in.) 0.375	Process			FASTENER INSTALLATION	Type	F.1	Torque (in th)
PHASE II -TASK 2BASIC OPEN HOLE VALUES	TEST_2T3 SPECIMEN_623078	COLDWORK PROCESS	Interfarence	Sleeve type	Sleeve thickness (in)	Sleeve or entation	Mante mairial	Mandre' taper (in /in.)	Mandrel max diameter Inn).	Lubrication
		SPECIMEN DESCRIFTION	Configuration 749.2	Material Ti-6At-4V (anneated)	Width (in)	Hole spacing (in)	Edge margin (in.) 0.75	Material gage Irn 0 250	Surface treatmen: Shot neen	

Origin of failure	and remarks												
C, cles	failure	41,000	000 (1)			39,000							
size (in)	Fit												
Fastener size (in)	Diameter												
Coldwork expension (in.)	Retained												
Cold	Actual												
В,	After	8	-			25	-						
Hole finish (RHR)	After coldwork												
¥ ;	Before												
	Atim	0.3755	0.3755			0.3755	0 3755						
Hole diameter (in)	After coldwerk												
Ho	Before coldwork												
101		-	2	3	4	-	2	٣	4	-	2	3	4
pecimen	ž č	ب				.7							

LUES

_DATE 8/30/73

SPECIMEN 623078

TEST 214

Ti-6Al-4V. reamed open. 50 ksi

	Normnal hole size (in) 0.375 Max net stress (ksi) 50	Process Ream Max test load (kip) 14.3	Load ratio (R) 0.1	Test frequency 4000 cpm	FASTENER INSTALLATION Test (aboratory Materials	Tylk Tylk	ter (in.) Test machine 36-kip vibraphore	Torque (in 1b)
HOLE PREPARATION					FASTENER INSTALLATION	Type	Ī	Torque (in lb)
							(u	
COLDWORK PROCESS	Interference	Steeve type	Sleeve thickness (in)	Steeve orientation	Manifel material	Mandrel taper (in /in)	Mandrel max diameter (in)	Lubrication
PTION	Fig. 2	Ti-6Al-4V (annealed)	1.50	1 50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material	Width (in)	Hole spacing (in.)	Edge margen (m.)	Material gage in).	Surface treatment	

Origin of failure	and remarks	{				{	\$ [- -	}	{			
			103.000					4					
Cycles	to failure	103,000	103,000			142,000							
Fastener size (in)	Fit	103,00											
Fastener	Diameter												
Coldwork expansion (in)	Retained												
Cole	Actual												
(R)	After	25	_			25	-						
Hole finish (RHR)	After coldwork												
ĭ	Before coldwork												
	After	0.3755	0 3755			0.3755	0.3755						
Hote diameter (in)	After coldwork												
ž	Before												
d G		_	2	3	4	_	2	3	4	_	2	3	4
Specimen	daeth Or	ġ.				10							

Ti 6Ai 4V. reamed open. 55 ksi		FATIGUE CONDITIONS 55	Max net stress (ks)	Max test load (kip)	Load ratio (R) Anno com	Test frequency	Test laboratory Materials	Test engineer D. NESS	Test machine	
II-TASK 2- BASIC OPEN-HOLE VALUES	TEST 215 SPECIMEN 623078 DATE 8/30/73	IK PRICESS HOLE PREPARATION	Nominal hole (12e lin.)	Process Process	Steeve thickness (in)	Sleeve or entation	Manite' material FASTENER INSTALLATION	Mandrel taper (in /in)	Mandrel max diameter (in)	Torque (in 1b)
PHASE		SPECIMEN DESCRIPTION COLDWORK	Configuration Fig. 2 Interference	Ti 6Al 4V (annealed) Sleeve typ	Width Im Steeve	Hole specing (in.) 1.50 Streve	Edge margin (in) 0.75 Mandi	Material gage (in.) 0.250 Mandi	Surface treatment Shot peen Mand	ריסאוניזויסט

Origin of failure	and remarks	}	}			}-						7	
Cycles	failure	42,000	42,000			57,000				000,711			
size (in)	Fit												
Fastener size (in)	Diameter												
Coldwork expansion to 1	Retained												
Cold	Actual												
æ	After	30	,			52	1			22	1		_
Hole finish (RHR)	After												
¥	Beture coldwork												
-	Afree	0.3755	0.3755			0.3755	0.3755			0 3755	0 3755		
Hole diameter fin I	After												
f	Before												
	10 S	-	2	(.)	4	-	~	3	4		،،	۶,	4
	dash on	8				=				-12			

Ti-6AI-4V C&W open, 60 ksi

FATIGUE CONDITIONS Max net stress (ksi) Max test load (kip) Test frequency Test laboratory Load ratio (R) Test engineer Test machine Ream, C/W, ream 0.375 DATE 8/30/73 FASTENER INSTALLATION Nominal hole size (in) HOLE PREPARATION Type Process SPECIMEN 623078 Ē AISI 9260 steel 0.045 0.353 0.019 0.010 Split °o TEST 2T6 Mandrel max diameter (in.) Mandrel taper (in /in) Sleeve thickness (in) COLDWORK PROCESS Interference (in.) Steeve orientation Mandrel material Sleeve type Ti-6AI-4V (annealed) Shot peen 0.250 0.75 1,59 1.59 SPECIMEN DESCRIPTION Hole spacing (in)

36 kip Vibraphore

Torque (in. /b)

Fet Pro 300

Lubrication

Material gage (nn.). Surface treatment.

Edge margin (in)

Configuration

Width (in) Mater al

4000 cpm Materials D. Reese

	and remarks	-	cw cw			{	Cw						
Cvclss	to	117,000				116,000							
Fastener size (in)	Ĭ.												
Fastener	Diameter												
Coldwork expension (in.)	Retained	0.0085	0.0000			0.0085	0.0000						
Colc	Actual	0.0185	0 0185			0.0185	0.0185						
â.	After	92	<u> </u>			25	-						
Hole limsh (RHR)	After coldwork	12	,			12	ļ ,						
H	Before	25				25	;						
	After	0.3755	0 3755			0 3755	0.3755						
Hole diameter (in)	After	0 3630	0 3635			0.3635	0.3630						
Đ.	Before	0.3545	0.3545			0 3545	0 3545						
H Oie		-	2	8	4	1	2	3	4	-	2	<u>س</u>	4
Specimen	e e	:13				14							

BASIC OPEN-HOLE VALUES
- 1
1LTASK2
PHASE

	NS 50	14.1	•		4000 cpm	Materials	D. Heese	36 kip Vibraohore	
	FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
SPECIMEN 623078 DATE 8/30/73	HOLE PREPARATION	Norminal hole size (in) 0.375	Process			FASTENER INSTALLATION	Type	F1	Torque (a) lb}
TESTSPECIMEN_6		Interference (in.)	Split Sleeve type	Steeve thickness (in.)	Steeve orientation	Mandret material	Mandrel taper fin /in ł	Mandrel max diameter (in).	Lubrication Fel Pro 300
	SPECIMEN DESCRIPTION	Configuration Fig. 2	Material	1.50	1.50	Educ material (in)	0.250	Surface treatment	

_	* * * *			(-	- }	}		-	}	_)	7		{	-	<u> </u>	7		
	Origin of failure and remarks		C/W	<u>_</u> →					<u>}</u> -•			_ <u>_</u>		<u>.</u>			<u>_</u>		
	Cycles	Tailure Tailure	1 576 000	200,010					6,868,000					ı		-			
1	Fastenet size tin 1															+	 -		
	Fastener	Diameter																	
and it	Coldwark expansion (in)	Retained	1000	0.0030	0600.0				0.0085	0.0085				06000	0000	0.000			
3		Actual		0.0185	0.0185				0.0185	0.0185	3			0.0185	13	CB10.0			
		After		20	,				25					25	!	, 	_		
	Hale finish (RHA)	Afre		18	!				15					2	!				
	Ŧ	Before		జ	-	İ			25		, 			75.	3				
				0.3555	0.3755				0.3755	22.50	0.3755			0.2766	20,00	0.3755			
	Hote diameter (in)	After	COLOMOLY	0 3635	0.3635				0.3630		0.3630			20,00	0.3033	0.3635			
		3efor .	COLUMOTA	0.3545	0.3545				0.3545		0.3545			1	0.3545	0.3545			
		10 E		-	,	•	3	4	-		2	3	4		_	7			4
		Specimen dash no		.15	2		. –		16	?					-11				

			2 8	2	1.0	4000 cpu	Materials	O Neede	I CONTRIB	
C/W open.		FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
VALUES	SPECIMEN 623078 DATE 8/30/73	HOLE PREPARATION	Nominal hole size (in) 0.375	Process Ream, C/W, ream			FASTENER INSTALLATION	Type	Fit	Torque (in :lb)
PHASE II –TASK 2–BASIC OPENHOLE VALUES	TESTSPECIMEN_6	COLDWORK PROCESS	Interference 0.019	Steeve type	Steeve thickness (in.) 0.010	Sleeve orientation.	Mandret material AISI 9260 steel	Mandret taper (in./in.)	Mandrel max diameter (in). 0.353	Lubrication Fel Pro 300
PHA		SPECIMEN DESCRIPTION COLDY	Configuration Fig. 2 Inte	Material Ti 6Al-4V(annealed) Sie	Width (in) 1.50 Slee	Hole spacing (in.) 1.50	Edge margin (in.) 0.75 Mar	Material gage (in) 0.250 Mai	Surface treatment Shot peen Mar	Lut

Origin of failure						3							
Cycles	failure	76,000				64,000							
size (in.)	Fastener size (in.) meter Fit												
Fastener	Diameter												
Coldwork expansion (in)	Retained	0.0090	0.0000			0.0000	0600.0						
Cold	Actual	0.0185	0.0185			0.0185	0.0185						
8)	After	92				20	_			_		\dashv	
Hole finish (RHR)	After coldwork	10				12	1						
Ĭ	Before coldwork	20	i			25	1						
	After	0.3755	0.3755			0.3755	0.3755						
Hole diameter (in.)	After	0.3635	0.3635			0.3635	0.3635						
H _O	Before	0.345	0.3545			0.3545	0.3545						
	Hoir	-	2	3	4	_	2	6.)	4	-	~	(*)	7
	Specimen dash no	.18				9							

PHASE 11-TASK 2- BASIC OPEN-HOLE VALUES

TEST_2T9___ SPECIMEN__623078_DATE_8/30/73_

ð. A	18.7	0.1	4000 сыт	Materials	D. Reese	100 kip Vibraphore		
FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (RID)	Coad ratio (ra)	Test frequency		lest engineer	Test machine	
	0.375	Deglin, CVV, Tellin			NO.			
HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Fit	Torque (in lb)
	6100	Split	0.010	0	AISI 9260 steel	0.045	0.353	Fel Pro 300
COLDWORK PRCCESS	Interference (in.)	Steeve type	Steeve thickness (in)	Sieeve orientation	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (in)	note some
PT ON	Fig. 2	Ti-6AI-4V (annealed)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPT ON	Configuration	Materia ⁱ	Width (in)	Hole spacing (in)	Edge margin (in)	Material gage (in.)	Surface treatment	

•

Origin of failure					•	CW)	}					
Cycles	failure	88,000				104,000						_		
Fastener size (in)	Fit			-:-							1		-	
Fastener	Diameter													
Coldwork pansion (in)	Retained	0.0095	06000			9600.0	0600.0							
Coldwork expansion (in)	Actual	0.0185	0.0185			0.0185	0.0185							
â	Atter	25	!			25		-						
Hole finish (RHR)	After coldwork	12				55								
ş I	Before	25				30								
	Atter	0.3755	0 3755			0.3755	0.3755							
Hole diameter (in.)	After	۱_	0 3635			0.3640	0.3625							
Hol	Before	0.3545	0 3545			0.3545	0.25.45	25.5						
	J. O.	-	2	٣	٩	, -	، إ	,	٣	4	-	~	9	4
	Specimer dash no	۲				3,	•							

Ti 6A1 4V sta, reamed open, 70 ksi

TEST_2T10___ SPECIMEN_623078__DATE_9/11/73_

ν	70	20.3	0.1	4000 cpm	Materials	D. Reese	100 kip Vibraphore	
FATIGUE CONDITIONS	Max net stress than 70	Max test loar (kip) 20.3	Load ratio (R)	Test frequency	7 rst laboratory	Test engineer	Test machine	
	3/8	3/8 Drill and ream			20			
HOLE PREPARATION	Naminal hole size (in)	Process			FASTENER INSTALLATION	Type	÷.	Torque fin 1b)
COLDWORK PROCESS	Interference	Sireve type	Steeve thickness (ir.)	Strave or writation	Mandret material	Mandrel taper (m /m)	Mandrel max diameter (iii)	Ludrication
NO.	Fig. 2	Ti-6Al-4V (sta)	1 50	1 50	0 75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material	Width (m)	Hole spacing (in:	Edge margin fin 1 075	Material gage (in)	Surface treatment	

	·	{	- } €	-	7	(} (7		(5	7
	cles Origin of failure				Bow, 0.20 in.				80w, 0.19 in				Bow. 0.18 in
Cycles	failure	26,000		 		30,000				36,000			
Fasterner size fin l	ĭ												1
Fastener	Diameter		 										
Caldwork expension (-n-)	Retained		 - -						İ			 	
Colle	Actual		i i										
<u> </u>	After	8		 		35				30			
Holi: finish (RHR)	After										 	i i	
P.6	Before												
-	Afrer	0.3755	0.3755			0.3755	0 3755			0 3755	0 3755		
Hole dameter In }	Afrecoldwork												
Ţ.	Before											 	
HOIE			2	3	+	-	2	3	4	-	2	3	4
Specimen	90 Oc	-1 sta				-2 sta				3 sta			

A STATE OF THE PROPERTY OF THE

PHASE II - TASK 2 - BASIC OPEN HOLE VALUES

DATE 9/12/73 SPECIMEN 623978 TEST_2711__

Ti-6AI-4V, sta, C/W open, 70 ksi

Si Or		20.5	0.1	4000 срт	Materials	D. Reese	100-kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ksi)	Max test loan (kip)	Loadratio (R)	Test frequency	Trist laboratory	Test engineer	Test machine	
;	3/8	Drill, ream, C/W			z			
HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Fire	Torque (in 1b)
	0.019	Split	0.010	0	AISI 9260 steel	0.045	0.353	
COLDWORK PROCESS	Interference (in.)	Steeve type	Sleeve thickness (in.)	Sleeve orientation,	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (in)	Lutwicstion
TION	Fig 2	1.6A1.4V (sta)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material	Width (m.)	Hate spacing (in)	Edge maryin lin.	Material gage (in)	Surface freatment	

Origin of failure	Origin of failure and remarks				Bow, 0.086 in.	→ **		}	Box, 0.172 in (twisted)	→85			Bow, U.083 in.
Cycles	to failure	81,000				85,000				51,000			
Fastenei size (in)	ř.												
Fastenei	Diameter												
Colitwork expansion lin l	Retained	0.9085	0.0085			0.0085	9800.0			0.0085	0.0085		
Colfd	Actual	0.0085	0.0085			0.0185	0.0185			0.0185	0.0185		
=	After	35				ಜ				8	:		
Hole finish (RHR)	After	20	-			8	,			50			
ř	Before coldwork	35				40	-			40			
_	Atter	0.3740	03740			0.3740	0.3740			0 3740	0 3740		
Hole diameter (m.)	After	0.3630	0.3630			0 3630	0.3630			0.3630	0 3630		
Ş	Before	0 3545	0.3545			0.3545	0.3545			0.3545	0.3545		
	Hole 10	-	2	3	4	-	2	3	4	-	2	3	4
300	det dest	4 sta				.5 sta				6 sta			

DATE 9/11.73

Ti 6Al 4V, s' ..., reamed open 70 ksi

4

100 kip Vibraphore D. Reese Materials 400 cpm 8 0 FATIGUE CONDITIONS Max net stress (ksil. Max test load (kip) Test frequency. Test laboratory Load ratio (A) Test machine Test engineer Drill and ream 3,8 FASTENER INSTALLATION Nominal hole size (in.) HOLE PREPARATION Torque (in Ib) Process SPECIMEN 623078 TVD ÷ TEST_2712 Mandrel max diameter (in) Mandrel taper (no /no l Sieeve thickness (in) COLDWORK PROCESS Sieeve orientation Mandrel material Steeve type Interference Ti-6Al-4V (stoal Shot peen 0.250 Fig. 2 1 50 0.75 1.50 SPECIMEN DESCRIPTION Surface treatment Material gage fin ? Edge margin (in.) Configuration Male spacing Width Lin : Mater ⋅3

Lubrication

Origin of failure	and remarks	}											
Cycles	tailure	30,000				32,000				33,000	_		
Fastenet size (in)	ū												
Fastoner	Diameter												
Coldwork expansion (ir.)	Retained												
Cold	Actual												
â	After	25	,			40	-			35			
Hole funish (AHR)	Atter									. —			
Ĭ	Before												
-	After	0.3755	0.3755			0.3755	0.3755			03755	0 3755		
Hole diameter In 1	Afre												
Ť	Before												
	io.	-	2	.,	4	-	2	8	4	-	~	2	4
	dash	·1 stoa				2 \$100				3 stoa			

Ti 6Al 4V stoa, C/W open, 70 ksi

TEST_2T13_ SPECIMEN_623078__OATE 9/12/73_

ows 70	20	0.1	4000 cpm	Materials	D Reese	100-kio Vibraphore		
FATIGUE CONDITIONS	Man net stress tast	Mar test load (kip)	Load ratio (R)	Test frequency	A STREET, IC	Test engineer	Test machine	
8/2	•	Orm, ream, Ora			NO			
HOLE PREPARATION	Norminal hole size (in)	Process			FASTENER INSTALLATION	Type	F	Torque (m lh)
	0.019	Split	0.010	0	AISI 9260 steel	0.045	0.353	Fe! Pro 300
COLDWORK PROCESS	interterence (in.)	Steeve type	Signive thickness (in)	Sieeve of rentation	Mandrel material	Mandrel taper tin /in.)	Mandkel max diameter tin i	
TION	Fig. 2	Ti-6AI-4V (stoa)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material	Width (in)	Hole spacing (in.)	Edge margin in)	Material (age f.n.)	Surface treatment	

	Origin of failure	and remarks							*8	;					+35					
	Cycles	Taries Springe	20.00	00000				 000 00	38,000					300	00.00		-	1		
	Fastener size lin j	i				L		-									-	1		
	F ASTROPE	Diameter																		
Coldanic	I mil noismedini	Retained		0.0095	0.0095				5600.0	3000	0.000		L		0 0095	0.0095				
5	Shedra	Actual		0.0185	0.0185	•	9		0.0185		20		<u> </u>		0.0185	0.0185	,			
	á	After		32	,				35						35	 -	- 			
	Hote finish (RHB)	Mier		8	,				2				 		15	 -	-			
	Ĩ	Before	2000	46					40		:				35		.			
	_	After	LL GALL	0.3740	0 3740	2			0.3740		0.3740				0.3740		0.37.35			
	Hole diameter (in)	After	COLDWOTK	0.3640	0.2640	0.3010			0.3640		0 3640				0.3640		0.3640			
	1401	Before	colchwork	0 3545	0.25.40	0.3540			0.3545	2.6.0	0 3545				0.3545		0.3545			
		¥ 5		-	. (7	3	4	-		2	,~	ì	4	-		7	8		4
		Specinen dash no		4 stoa						POIS C					200 9	2000				

PHASE 11-TASK2 - BASIC OPEN-HOLE DATA

2714 SP_CIMEN 623078 DATE 10/1/73

T, 6A1 6V 2Sn, reamed open 70 ksi

	TIONS 70	1	•	4000 cpm	Materials	D. Reese	36-kip Vibraphore		
	FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (Kip)	Loadratio (R)	Test frequency	I est laboratory	Test engineer	Test machine	
		0.3/5	niegu.			N.			
DATE	HOLE PREPARATION	Nominat hole size lin 3	Process			FASTENER INSTALLATION	Tvpe	Fit	Torque (in. lb)
TEST 2114 SPL SIMEN CESTON									
TEST_	COLDWORK PHOCESS	Interference	Sleeve type	Sleeve thickness (in)	Steeve or entation	Mandrel material	Mandrel taper lin (in)	Mandre) max diameter (in.)	Lubrication
	SPECIMEN DESCRIPTION	Configuration.	Ti-6AI-6V 2Sn (annealed)	1.50 Midth (m)	Hole spacing (in) 1.50	Edge margin (in) 0.75	Material gage fin J 0.250	Surface treatment Shot peen	
	SPECIA	ò	Marerial	W	Ĩ	m e	ſΛa	Sur	

Origin of failure	and remarks			-									
Cycles	failure	51,000			200	33,000			28,000	200.00			
Fastener size tin I	ī											1	
f astener	D:ametir												
Coldwork expansion fin 8	Retained												
Coli	Actual												
	After	8	25			- 15	15	_	_	15	15		
Hole finish (RHR)	Attur												
Ť	Bufore												
-	After	03750	0.3750			03750	03750			0.3750	03750		
Hole dameter in 1	After												
H	Before												
	¥ 0:	-	2	3	4	_	2	3	4	_	2	E	4
	Spec men della no	1.662				2 662				3.662			

RASIC OPEN.HOLD DATA	
II TACK 2 B	11/50
DHACE	֓֝֝֡֜֝֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֓֡֓֓֓֡֓֓֓֡֓֓֓֡

Ti 6Al 6V 2Sn. C/W open. 70 ksi

	1651		SPECIMEN 623078 DAYE 10/11/73	1/73		
SPECIMEN DESCRIPTION	COLDWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS	Ñ
Configuration Fig. 2	interference (in.)	0.019	Nominal hole size (in)	0375	Max net stress (ksi)	07
Tr.6Al-6V-2Sn (annealed)	aled) Sleeve type	Split	Process	Ream, C/W, ream	Max test load (kip)	20.3
Width In 1	Steeve thickness (in.)	0.010			Load ratio (R)	0.1
Hole spacing (in)	Sleeve orientation	0			Test frequency	40:00 cpm
Edge margin (in)	Mandrel material	AISI 9260 stee!	FASTENER INSTALLATION		Test laboratory	Materials
Material gags (in.)	Mandrel taper (in./in.)	0.045	Type		Test engineer	D. Reese
Surface treatment	Mandrel max diameter (i) 2.	0.353	F.		Test machine	36 kip Vibraphore
		Fet Pro 300				

Origin of failure	and remarks	_	W.S.			-	Cw			→	N'O N		
Cycles	faiture	50,000				70,000				79.000			
Fastener size (in .	F.1												
Fastener	Diameter												
Coldwork expansion (in)	Retained	08000	0.800.0			0.0080	06000			0.0080	0.0080		
Colc	Actual	0.0190	06100			0 0 1 9 0	06100			06100	06100		
æ	After	20				22				25			
Hole fraish (RHR)	After	20	,			20	ı			50	-		
¥	Beton	35				35				35			
-	After	03750	03750			0.3750	0.3750			0.3750	03750		
Hole diameter (in !	After	03620	0.3620			0.3620	0.3630			0.3620	0.3620		
P	Before coldwork	0.3540	0 3540			0.3540	0.3540			0.3540	03540		
30		-	2	ن	7		e:	~	*	_	2	3	9
Specimen	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	4.662				299-5				299.9			

Ti 6A16V 2Sn sta, reamed open, 70 ksi	FATIGUE CONDITIONS	Max net stress (ksi) //U	Max test toad kipl 20	Labdratio (R)	Test frequency	Test laboratory Waterials	Test engineer	Test machine	
.E DATA 23078 DATE 10/1/73	HOLE PREPARATION	Nominal hole size lin) 0.375	Process			FASTENER INSTALLATION	Type	File	Taroug (in ib)
PHASE II - TASK 2 - BASIC OPEN-HOLE DATA	COLDWORK PROCESS	Interferance	Steeve type	Steeve this kness (cn.)	Sieeve Orier (2010).	Manifel material	Mandrel taper (in./in.)	Manchel max distinctor (in)	
	SPECIMEN DESCRIPTION	Configuration Fig. 2	Material Ti-6AI 6V-2Sn (sta)	1.50 Width (in)	Hole spacing (in.)	Edge margin lin ?	Material gage (in.)	Surface treatment	

Origin of failure	and remarks	_											
Cycles	laviure	22,000				23.000				24,000			
Fastener size (in ;	ř.												
Fastener	Stameter												
Coldwork expansion (in)	Retained												
Cost	Actual												
ã	Altr	25	-			5				5	,		
Hole firmsh (RHR)	After coldwork												
F	Before coldwork												
-	Atter	03750	03750			03750	03750			0.3750	0.3750		
Hale diameter (in.)	After												
£	Before												
	ğ e	[-	2	3	4	-	2	3	4		2	3	4
	15 OF	1.662				299.Z				3 662 sta			

PHASE II - TASK 2- BASIC OPEN HOLE DATA

T, 6At-6V-2Sn sta, C,W open, 70 ksi

	IDIT:ONS	70 (18) 70 (18)	d (kip) 20	•			•	So-kip Vioraphore	
	FATIGUE CONDITIONS	Max net stress Iksi)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory.	Test engineer	Test machine	
1/73			Ream, C.W. ream			NOI			
SPECIMEN 623078 DATE 10/11/73	HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	ī	1 1 1 1 1 1
TEST 2717 SPECIMEN		0.019	Split	0.010	0	AISI 9260 steel	0.045	0.353	Eal Pro 200
1651	COLDWORK PROCESS	Interference (in.)	Sieeve type	Seeve thickness (in)	Sleeve orientation	Manchel material	Mandrel taper (in.in.)	Mandrel max diameter (in).	
	PTION	Fig. 2	Ti-6Al-6V-2Sn (sta)	1.50	1.50	0.75	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Material	Width (in)	Hole spacing (in.)	Edge margin (in)	Material gage (in.)	Surface treatment	

Origin of failure	and remarks	C.W.				- 3				t-Cow			
Cycles	failure	000'91				94.000				72.000			
Fastener size (in)	ĩ												
Fastener	Diameter												
expension (in)	Retained	0 0085	0.0085			0.00080	0.0085			0 0085	06000		
2 60 2	Actual	0.0190	00100			0610.0	0 0 1 9 0		_	0 0 1 9 0	0 0 1 9 0		
ē	After	8	'			52			_	93	,		
Hale finish (AHR)	After	8				20				20	:		
Ĭ	Before	35	:			35				35			
	Alter	0.3745	0 3745			0.3745	0 3745			0 3745	0.3745		
Hole diameter (in)	After	0.3625	0 3625			0.3620	0.3625			0.3625	03630		
Ĭ	Before coichaoth	0.3540	0.3540			0.3540	0 3540			0 3540	0.3540		
	ž S	-	2	٣	4	-	2	3	4	-	~	(,,	4
	deg Sep	4.662				2995				299 9			

PHASE II-TASK 2- BASIC OPEN HOLE DATA

Ti-6AI 6V-2Sn stoa, reamed open, 70 ksi

2718 SPECIMEN 623078 DATE 10/1/73

	FATIGUE CONDITIONS	Max net stress (ksi) 70	Max test load (kip) 20	Load ratio (R) 0.1	Test frequency 4000 cpm	Test laboratory Materials	Test engineer D. Reese	Test machine 36-kip Vibraphore	
623078 DATE 10/1//3	HOLE PREPARATION	Nominal hole size tim.) 0.375	Process			FASTENER INSTALLATION	Type	F11	Torque (in 1b)
TEST_2718 SPECIMEN 523078	COLDWORK PROCESS	Interference	Sleeve type	Sleeve thickness Inn.	Sleeve orientation.	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (in).	Lubrication
	SPECIMEN DESCRIPTION	Configuration Fig. 2	Ti 6Al 6V 2Sn (stoa)	Wedth In 1	Hole specing (in). 1.50	Edge margin (in) 0.75	Material gage (in 1 0.250	Surface treatment Shot peen	

Origin of faiture	and remarks	{								{			
Cycles	faure	38,000				38,000				30,000			
Fastener size (in)	Fit												
Fastener	Diameter												
Coldwork expansion (in)	Retained												
Cold	Actual												
â	After	15	-			15	'			5	,		
Hole finish (AHR)	After												
Ĭ	Betor: coldwork												
	After	0.3750				0.3750	ı			0.3750	_		
Hole diameter (in.)	After coldwork												
Į.	Before coldwork												
	ş 5	-	2	3	4	-	2	2	4	-	2	3	4
3	to S	1 662 stoa				2.662 stoa				.3.662 stoa			

The state of the s

Ti-6Al 6V 2Sn stoa, C/W open, 70 ksi

PHASE II-TASK 2-BASIC OPEN-HOLE DATA

TEST_2T19_ SPECIMEN_623078__ DATE_10/11/73

FATIGUE CONDITIONS 70	Max test load (kip) 20	Load ratio (R) 0.1	Test frequency	Test taboratory Materials	Test engineer	36-kip Vibraphore	
HOLE PREPARATION	Nominal hole size (in.) Ream C/W, ream	Process		FASTENER INSTALLATION	- Acceptance of the control of the c	Fit	Torque (in. lb)
COLDWORK PROCESS	Interference (in) 0.019	Sleeve type Split Split	Sleeve thickness In I	Sleave orientation AISI 9260 steel	!	Mandret taber (in /in) Mandret max diameter (in)	Fel Pro 300
OFCRIPTION	Configuration Fig. 2	Ti 6Al-6V2Sn (stoa)	Width (in)	Hole spacing (in.)	Edge maryin lin /	Material gage (iii.) 0.250	Surface treatment

Lubrication

	Origin of failure			Cow			}			(w)		-	}			(My)			\			
	Cycles 50	failure	3	00./0					48,000						55,000			_				
Cartegor size lin.)		ī.							_		_		1		_			-	1	_		
3		Diameter																				
Coldwork	expension (in)	Retained		0800:0	0.0085				0000	0.0080	0.000				1000	C800.0	0.0085	-				
8	su e dxa	Actual		0.0190	00100					0.0190	06100			_		0.0190	0.0190					
	- -	Alte	£ 2									1			1			-			1	
	Hole finish (RMR)	After	coldwork	8		.				8						20						
	Ĭ	Before	COSCHWOTK	35						35		- 				% %		1				
}	_	, in	E PROL	0.3745	;	0.3745				0.3745		0.3745				0.3750		0 3750				
	Hole diameter (in.)		Coldwork	0.36.0	0.5020	0 3625				0.3620	2	0.3620				0.3625	3050	0 3625				
	Ť		Before	9	0.3540	0 3540				0.2540	0.3340	0.3540				32.0	0.550	0 3540				
		Hole	2			2		က	4	1	-	2	,	5	4		-	2	1	က	4	
		Sperimen	0:	555	4-002 stoa					5,662	stoa					6333	\$100					

PHASE 11-TASK 2 - BASIC OPEN-HOLE DATA

Ti 6AI 5V. C/W on::-3/4 in. 0, 70 Ksi

Company of the compan

TEST_2720 SPECIMEN 623078 DATE 10/74/73

100 kip Vibraphore 4000 cpm D. Reese Materials <u>.</u> 2 හු FATIGUE CONDITIONS Max net stress (ksi) Max test load (kip) Load ratio (R) Tist laboratory Tint frequency Test engineer Test machine Ream, C/W, ream 0.750 FASTENER INSTALLATION Nominal hole size lin) HOLE PREPARATION Torque (in 1b) Process Type F 12 Fel Pro 300 AISI 9260 Manderl max diameter (iii] 0.7140 0.045 0.030 0.015 Split Mandrel taper (in /in) COLOWORK PROCESS Siceve thickness (in f Interference (In.) Seeve orientation Manchel material Streve type Cubrication Ti-6At-4V (annealed) Shot peen Fig. 2 0.375 3 00 3.00 1.50 SPECIMEN DESCRIPTION Hote spacing (in) Material goge (in). Surface treatment Ertge margin tin J Configuration Width (in) Material

0.000	and remarks		W			{	w o			→	C.W		
Cycles	to failure	86,000				54 ,000				61,000			
Fastunce sizu fee t	r.												
Fastener	Diameter							1					
Cattlwork expansion (in)	Retained	0.0120	0.0120			00120	00100			0.0115	0.0115		
ic.	Actual	0 027	0 0 0 2 9			0 029	0.029			0 0 0 29	0 029		
23	Ather	25				8	·			35	:		
Hole finish (RHR)	After culdwork	15				20		! 		15		 	
Ħ	Before	25	-			æ	-			25	,		
-	Aher	0 7510	0 7515			0 7515	0 7505			0 7505	0.7575		
How diameter to 1	Atter	07270	0 7270			07270	0 7270			0.7265	0.7265		
Ĭ	Before	0.715	0715			512.0	5120			0715	0 715		
I S		-	2	3	4	_	2	3	4	-	2	3	4
Specimen	90°	25				56				27			

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PHASE II -TASK2 - BASIC OPEN-HOLE VALUES

	DATE
	623078
, notice, of	SPECIMEN
B ()	EST2S1

.o	105	29.4	0.1	4200 cpm	Materials	D. Reese	36-kip Vibraphore	
FATIGUE CONDITIONS	Max not stress (ks.) 105	Max test load (kep)	Load ratio IR	Test frequency	First taboratory	Test engineer	Test machine	
	3/8	Drill, ream, and hone			N.C	1	1	
HOLE PREPARATION	Noningl bolesize (in.)	Process Drill			FASTENER INSTALLATION	Type	Fit	Torone in its
	I	i	1	1	1	1		1
COLUMBRK PROCESS	e Pride gert bei Pride	Steeve 1ype	Siecue thukness lin k	Sleeyer or entation	Manderl material	Mandrel taper (in /in)	Mandel max diameter (in)	Section 1
	F.g. 2	300 M steel (270-300 ksi)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Can'iquiation	Material 300 M	Width tie)	Flobs space on	Edg. margin (in)	Material gage Inn }	Surface treatment Shot peen	

Origin of fadure	and remarks	}		Large zones	{			Large zones	{		\	Large zones
Cycles	to	43,000			24 000	200			42,000	42,000	i 	
sze (m)	53.7 51.1									İ	 	
Fastener size (in)	D.ameter											
Coldwork expansion (in.)	Retained											
Cok	Actual									İ	_	
£	Alter											
Hole finish (RHR)	After											
Ĭ	Before co-dwork											
_	After	0.3804	0.3804		0.3803	0.3803			0.3803	0.3803		
Hole diameter (in)	After											
£	Before											
	2	-	2	 4	-	2	e .	7	-	^	۳,	
Specimies	data no	-			7				-3		 	

PHASE II -TASK 2 - BASIC OPEN HOLE VALUES 300 M, Reamed, Open, 105 KSI

	SNO	30		7000 cpm	Materials	D. Brese	36. Lip Vibraphore		
	FATIGUE CONDITIONS	Maximelistress (kg.) 105	Max test toad (kip)	in) bits beo	A	A	i est engineer	Test machine	
.10/23		'	Drill and ream			ATION			1
SPECIMEN_623078DATE_7/10/73_	HOLE PREPARATION	Nominal holes (28 lin)	Process			FASTENER INSTALLATION	Type		I of the
TEST2S2SPECIMI		1			•	1		r (m)	
1631	COLDWORK PROCESS	/interference .	Steeve tyth	Steeve thickness In I	Sleeve orientation	Mandrel material	Mandrel taper In in I	Mandrel max diameter (iii).	
	NOIL	Fig. 2	300 M steel (270-300 ksi)	1.50	1.50	0.75	0.250	Shot peen	
	NOTAL DESCRIPTION	Configuration	Material 300	Width In !	Hote spacing	Edge margin (iii)	Maherial gage in)	Surface treatment	

	Origin of failure	and femality.	}				Large zones						Large zones	\ \ 				Large zones	
	Cycles	fasione	000 000	33,000					103,000						75,000				
	Fastener size (in)	£											_			_			
	Fastrner	Diameter																	
	Coldwork expension In)	Retained																	
,	expans	Actual																	
	î.	After	<u>ت</u>		!				8						15	!	1	-	
	Hale finish (RHR)	Atter																	
	Ĭ	Before																	
		After	0.275	32.5	0.375				0.375		0.375				0.375	3,00	2/20		
	Hote diameter Im	After																	
	Ho	Before																	
		101		-	2	-	3	4	-		2	~	'	4	-		7	3	4
		Specimen		4-					4	, !					9-				

PHASE II -TASK 2 - BASIC OPEN-HOLE VALUES

300 M, Reamed, Open, 110 KSI

7657 253 SPECIMEN 623078 DATE 7/10/73

NOITIONS	110 trus (kei)	and (krp) 31	(R) 0.1	7000 cpm	-1	•	36-kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ks)	Max inst load (kip)	Loadrano (R)	Test frequency	Test laboratory	Test enqueer	Test machine	
	3/8	Orill and ream			NOI	1	1	•
HOLE PREPARATION	Norman, hole size (m.)	Process			FASTENEH INSTALLATION	Type	fit .	Torque (in lb)
	1	1	l ,	1		1	n).	1
COLDWORK PROCESS	biterference	Steeve type	Steeve thit kness lin l	Sleeve orientation	Mandrel material	Mandrel taper (in un l	Mandret max diameter (in)	Collegation
71.ON	Fig. 2	300 M steel (270-300 ksi)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material 300	Walls to J	Profession	Edge margin (in)	Material gage (m.)	Surface treatment Shot peen	

Origin of failure	and remarks]	Large zones)	Large voites	{			
Cycles	failure	48,000				000'09						 	
Fastener size In)	Fit												
Fastener	Diameter												
Coldwork expansion (n.)	Retained												
Cole	Actual												
æ	After	20				92							
Hole finish (RHR)	After coldwork			ļ									
₹	Before												
_	Alter	0.3750	0.3745			0.3745	0.3745						
Hale diameter (in)	After												
H	Betore												
,	alok Pole	-	2	m	4	-	2	3	त	-	2	3	77
S. Control	tasb Oi					30							

PHASE II -TASK 2 - BASIC OPEN-HOLE VALUES

300 M, Reamed, Open, 120 KSI

TEST_254__ SPECIMEN_623078_DATE 7/10/23_

	Nominal hale size (in) 300 Man net sites (kv.) 120	32 Steeve type Process Orill and ream Max test load (kip) 32	Sheve thu kings (r.)	Sterve orientation	Mandrei maint al Fret initiativy Materials	Mandrel tance (in in) Type Type	Mandret max demeter (m.) Frt 78-in Mandret max demeter (m.) 36-kip Vibraphore	Lubreacon Torque (m lb)
Fig 2						Material gage (in) 0.250 Man		do.1

enter la nervo	s y server pue	()) [Large zone-one side	}			Large zone on: side	{			7
Cyries	failure		32,000				49.000						
Fastener size (in)	<u>:</u>												
Fastene	Diametir											<u> </u> 	
Coldwork expansion (in)	Retained												
Cole	Actual												
ē	Atter	8] 			20	<u>'</u>] 		
HOTE fraish (MMR)	After												
Ĭ	Before												
D.	After	0.3745	0.3745			0.3745	0.3745						
Hote chameter (in.)	After coldwark												
Ĭ	Before												
Pfch		-	2	3	4	~	2	3	4	-	2	3	4
Specimen	96	6,				- 10							

The second secon

PHASE II .. TASK 2 - BASIC OPEN-HOLE VALUES...

300 M, Reamed, Open, 100 KSI

TEST. 285 SPEC WEN 623078 DATE 7/10/23

		-	Torque (in lb)	i	Lubication		
36-kip Vibraphore	Test maghine		Fish		Manifer has demeter (in)	Surface treatment Shot peen	Sortace treatmen
D. Reesc	Test empireer	1	1 V.De	1	Mandret taper for (or)	0.250	Maternal gage fro 3
Materials	First Laboratory	2	FASTERER INSTALLATION	1	Mandret material	0.75	Edp. Hargin to .
7000 cpn.	Test frequency				Steerer or molation	1.50	Holy spacing
0.1	Load ratio (R)			i	Shower the kness (m.)	1.50	Waffb bo t
28	Max test load (kup)	Orill and ream	Percent		Show type	300 M steel (270-300 ksi)	Abaterias 300
100	Max net stress thur-	3/8	Nominal Perference for i	!	Interference	Fig. 2	Configuración
50	FATIGUE CONDITICIES		HOLE PREPARATION		COLDWORK PRINCE 35	NO.130	SPECIMEN DESCRIPTION

Origen of fasture	and remarks	}			Large zone- one side	{			Large zone one side				
Cycles	for *adure	113 000	200,5			400 000	200,000						
Easteiner sich für)	<u>-</u> غ												
f.astoner	Pagenter										1	!	
Caldwark reparent (m.)	Fortamen			:									
بخاد	יעמים,												- 1
H)	Atter	20	:			8	1				Ĺ_	_	
Hote feast IRMR)	Atter												
I	Before					!							
-	After	0.3745	03745			0.3745	0.3745						
Foot stampta to !	Alter												
અન	Bulone intakath												
ig		-	2	3	4	1	2	3	4	-	2	2	17
threat work	dash 90	11:				.12							

PHASE II -TASK2 - BASIC OPEN: HOLE VALUES

300 M, C/W, Open, 100 KSI

SPECIMEN 623078 DATE 7/26/73 TEST 256

SPECIMEN DESCRIPTION	3.PT.ION	COLDWORK PROCESS	K PHOCE SS			HOLEP	HOLE PREPARATION	2		FATI	FATIGUE CONDITIONS	·9.7
Configuration	F19.2	Interference	nce (in.)	0.023/ 0.024	0.024	, For	Nominal hole size (en.)		3/8	1	Max out steess (ks)	100
Material 30	300 M steel (270-300 ksi)	Siegar lythe	<u>k</u>	Push (n	Push (no sleeve)	Proces	Ŕ	Real	Ream, C/W, Ream		Max test load (kip)	28.2
Wedth last	1.50	Sireve th	Sieger that kness (ict.)	'						ž	Load ratio (R)	0.1
Flore Spacing	1.50	Sleeve or	Sleeve orientation							Ė	Test frequency	4200 cpm
Edge cargo tin)	0.75	Mandret	Mandret material Car	Carbide (BAC 5972)	5972)	FASTE	FASTENER INSTALLATION	1 ATION		-	Test laboratory	Materials
Material gage (in)	0.250	Mandrel	Mandrel taper (in /in)	0.045		TVP		l	i	۰ ا	Test improper	D. Reese
Surface treatment	Shot peen	Manchel	Mandrel max diameter (iii) 0.358	") 0.358		ř	1	١	:	1	Test machine	100 kip Vibraphore
		ן טלאוכאזי	Lutercation Fel Pro 300 in hole and on mandrel	00 in hole a	pue	Ton	Torque for thi	1		1		
Note: Spiral	Note: Spiral reamer marks in holes from withdrawal, coldworked holes more difficult to ream	om withdraw	al, coldworke	d holes mor	re difficult 1	to ream	-					
	Hole diameter (iii.)	<u> </u>	Hote	Hote finish (AHR)		Coldwork expansion (in.)	Ork o tra)	Fasterier size fin	size (m)	Cycles		Origin of failure
Specialization Hole		+	-		-	- -				2		and remarks

	Origin of failure	and remarks				0.095 in. bow	*		Large zones	0.049 in bow	{			
	Cycles	failure	000'66				132,000							
	Fastemer size (in)	r.				_								
	Fasterier	Diameter												
	Caldwark expansion tin)	Retained	5/10.0	0.0180			0.0175	0.0175						
ult to ream	COIC	Actual	0.0245	0.0245 0.0180			0.0245	0.0245						
ore diffic	2	Atter	8	,			25	,					_	
red holes r	Hote fansk (AHR)	Alter	5	1			ß	-						
val; coldwo	Ĭ	Betore	20	!			2							
m withdra		After	b _{0.3765}	0.3745			0.3725	0.3740						
Note: Spiral reamer marks in holes from withdrawal, coldworked holes more difficult to ream	Hole diameter (iii)	After	0.3510	0.3515			0.3510	0.3510						
eamer mark	ĭ	Befor coultwee k	0.3335	0.3335			0.3335	0.3335						
Spiral		<u>.</u> 3	-	2	3	4	_	2	m	7	-	7	6	4
Note	0 di	de de	- 13				1-14			 -				

of aken at minimum (midpoint)

Note in hole where reamer failed, did not fail at step or stepped hole

PHASE II -TASK 2 - BASIC OPEN-HOLE VALUES

300 M, C/W, Oven, 105 KSI

TEST 257 SPECIMEN 623078 DATE 7/27/73

	105	29.3	0.1	4200 cpm	Materials	D. Reese	100 kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ks.)	Max test load thinh _29.3	Load ratio (R)	Test frequency	Tive lationatory	Test engineer	Test marbine	
	3/8	Ream, C/W, ream			20			
HOLE PREPARATION	Mominal Pole size (in)	Process			FASTENER INSTALLATION	1 v pr	F.	Torque (n. 163
	0.0245	Push (no sleevel	ı	i	Carbide (BAC 5972)	0.045	(11) 0.358	Fel Pro 300 in hole and
COLDWORK PROCESS	hilpertratence (in.)	Sireve type	Signate the kness (m.)	Storing Orientation	Mandret material	Mandret tager (in 'in)	Manchel max (hameter (m.) 0.358	Fel
NO	F 19. 2	300 M steel (270-300 ksi)	1.50	1.50	0.75	0.250	Surface treatment Shot peen	
MOLTOLOGICA DATA MATERIA ROLL	Configuration	Material 300	Width Lin)	Property along	Edge margin (in.)	(Aaterial gage fin)	Surface treatment	

e difficult to ream.	
ed holes more dif	
awal; coldwork	
es from withdr	
reamer marks in holes fro	
Spiral	
.ato	

Origin of failure	and remarks	CW		Large zones	0.120-in bow	₹ .		Large zone-one side	0.102-in. bow	\$ -		Hole not cleaned up	this side; 0.076 in bow
Cycles	fo	24,000				72,000					71,000		
Fautener wze (m.)	٤٠١										; ;	-	
Fa.tener	Diameter											i I	
Coldwork expansion (in l	Retement (a)	0.0185	0 0 0 1 9 0			0.0180	0.0180			0.0175	0.0175		
Coldwork expansion (iii	Actual	0.0245	0.0245			0.0745	0.0245			0.0245	0 0 2 4 5		
=	Alter	20				20	-			20	'	i	
Hole finish (RHH)	After coldwork	5	1			2	,			5	1		
Ë	Before	15	 			20	-			20	1		
(6)	After	0.3745	0.3740			0.3740	0.3740			0.3740	0.3740		
Hole diameter (in	After	0 3520	0.3525			0.3515	0.3515			0.3510	0.3510		
Hof	Before	0 3335	0 3335			0.3335	0.3335			0.3335	0.3335		
	1 S	-	2	,,	4	-	,	m	7	-	2	8	
Hole diameter	derh derh ne	15				. 16				11			

³Taken at minimum (midpoint)

PHASE II - TASK 2 - BASIC OPEN-HOLE VALUES

300 M, C/W, Open, 110 KSI

TEST 258 SPECIMEN 623078 DATE 7/27/73

NS 110	31	4200 com	Materials	D. Reex	100 kip Vibraphore	
FATIGUE CONDITIONS	Max test load (kip)	Load ratio (A)	The laboratory	Test engineer	Test machine	
3/8	Ream, C/W, ream				1	-
HOLE PREPARATION	Norminal Policy (in) Process			FASTENER INSTALLATION		Torque (m. 1b)
0.0246	Push (no steeve)	, }	1	Carbide (BAC 5972)	0.358	Fel Pro 300 in hole
COLDWORK PHOCESS	Literference (III.) Sleeve IVD*	Stream thuckness fin t	Sleeve unentation	Mandret material C	Mandret taper In /n) Mandret max diameter (m.) 0.358	a H
(300 M steel (270-300 ksi)	1.50	1.50	0.75	Shot peen	
SPECIMEN DESCRIPTION	Configuration 300 M	Walth for J	Mole spacing	Es germanique (val)	Marginal (page for) Si chice treatment	

Lubrication and on mandrel and on mandrel Aote. Spiral reamer marks in holes from withdrawal; coldworked holes more difficult to ream.

			}	T	7		- (}		-	}		{				7		
Origin of fature and remarks			Large zones	0.078 in. bow	* /2				0.070-in. bow										
Cycles	failure		41,000					62,000			-			-		 			
Fastener size tin l	<u>:</u>										 - -	-		+	_	 	+	_	
Fasterve	Diametry														_				
Coldwork expansion (in)	Retailwid		0.0180	0.0180				0.0170	0.0170								-		
expans	Actual		0.0245	0.0245				0 0245	0.0245	-				-			-		
.~	After		!	-				20	!	-			-			1		<u> </u>	
Hote finish (RHR)	After		S	;				ß	'			_			 		,		-
Ĭ	Hefore		20	1				20	\ \ \	1									
	After		0.3745	b _{0.3795}				0.3745	0.3245					~				 -	1
Hale diameter fin	A	(e) (e)	0.3515	0.3515				0,3505	3036.0	0.3303									
Ē	_	CO-COMOLE	0.3335	0.3335				0.3335	2 2 2	0.3333									
	HO1		-	2	6		4	-	1	7	~			-	1	7	7],	,
	Specimen		-18					9				}	Ì		1				

'Taken at minimum (midpoint)

^bReamer failed (step in hole), did not fail in this hole

PHASE II -TASK 2 - BASIC OPEN-HOLE VALUES

3C9 M, C/W, Open, 115 KSI

TEST_259_ SPECIMEN_623078_DATE 7/27/73_

5.7	115	32	4200 2020		Materials	O Reex	TOD-Kip Vibraphore	
FATIGUE CONDITIONS	Max net stress liked	Max test load (kip) 32	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	3/8	Ream, C/W, ream			Z O	i	1	i
HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Ē	Torque for (b)
	0.0245	Push (no sleeve)	1		Carbide (BAC 5972)	0.045	(m) 0.358	Fel Pro 300 in
COLDWORK PROCESS	tuterference (in.)	Sheve type	Sheve the kness (m.)	Signar onentation	Mandrei material C	Mandrel taper lin 'in)	Mandrel max diameter (m.) 0.358	Lubrication
20	Fig. 2	300 M steel (270-300 ksi)	1.5	1.5	0.75	0.250	Shot peen	
MOLEGIS DESCRIPTION OF THE PROPERTY OF THE PRO	north and the Co	Moterial 300 A	Wedth Let 1	Hole Spacing	Edge margno ho)	Material gage (in)	Surface treatment	

	Origin of failure	and temarks	CW		0.023 in. bow	3		0.112.jo			}	
	ر دورج	forute	127.000			46.000						
	Fasterier size I'm I	Ī							_		-	
	Fasterie'	Diameter										
Coldwork expansion in t	Retained (a)	0.0165	0.0165		0.0175	00175						
21	Cold	Actual	0.0245	0.0245		0.0245	0.0245				_	
	æ	After	20	_		20				- 		
KKEN HOIES	Hole finish (RHR)	After coldwork	5	1		S	1					
Wal colowe	H	Before	15	-		ន	!					
om withdra		After	0 3745	0.3745		0.3745	0.3745					
Note: Spiral reamer marks in holes from withdrawal, coloworked fluics finded in the control of t	Hole diameter (cn.)	After	0.3500	0.3500		0.3510	0.3510					
reamer mark	Ì	Before	0.3335	0.3335		0 3335	0 3335					
Spiral		F 2	-	^	3	 -	2	~	-	2	2	4
Note		Sash Sash Sash	-20			5						

^aTaken at minimum (midpoint)

	PHASEII -TASK2	PHASEII -TASK2 - BASIC OPEN-HOLE DATA	OLE DATA	300 M.	
		!		open, C/W, 3/4-in, hole	
	11510	11510 SPECIMEN 62380	62380 DATE 10/15/73	110 ksi	
SPECIMEN DESCRIPTION	COLDWORK PROCESS		HOLE PREPARATION	FATURE CONCIDENS	.,
Configuration Fig. 2	Interference (in.)	0.6450.0.046	Nominal hole size (in) 0.750	Max nel stress (ks.) 110	110
Material 300 M steel (270-300 ksi)	Sleeve type	Push no sleeve	Process Ream, C/W, ream	Max test load (kip)	53.2
Width (in) 3.00	Sleeve thickness (in.)	1		Load ratio (R)	0.1
Hole spacing 3.00	Sleeve orientation	1		Test frequency	4000 cg
Edge margin (in)	Mandrel material	Carbide (BAC 5972)	Carbide (BAC 5972) FASTENER INSTALLATION	Test laboratory	Materia
Material gage (ii)) 0.375	Mandrel taper (in /in)	0.030	Type	Test engineer	D. Rees
Surface treatment. Shot peen	Mandrel max diameter Im) 0.7325	0.7325	Fit	Test machine	60=80-1
	Lubricition	Fel Pro 300	Torque (in ib)		Vibraph

Orign of failure and remarks		[}		Failed in grip		C/W			-	CW		
Cycles	tailure	100,000				75.000				210.000			
Fastener size (in.)	, Fee												
Fastener	Diameter												
Coldwork expansion (in)	Retained	0.0285	0.0290			0.0295	0.0295			0.0240	0.0290		
Cole	Actual	0.0450	0.0455			0.0450	0.0450			0.0450	0.0450		
₽	After ream	75	65			0,	<u>'</u>			6			
Hole finish (RHR)	After coldwork	55	1			55	ı			55	ı		
Ĭ	Before coldwork	110				110	ı			110	,		
	After	0.7485	0.7490			0,7485	0,7485			0.7480	0.7485		
Mole diameter (in)	After coldwork	0917.0	0.7160			0,7170	0,7170			0.7165	0.7165		
Ho	Before	0.5875	0.6870			0.6875	0.6875			0.6875	0.6875		
H 9 9	ō.	-	2	3	Φ	-	2	3	4	1	2	3	4
Specimen	00	-25				-26				-27			

TEST	NUMBER:	3A 1	

NICALINIAL	EXPANSION	MALLIE.	-
NOMINAL	EXPANSION	VALUE:	

GENERAL TEST CONDITIONS

RAL TEST CONDITIONS	DATE:
Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2	Sleeve type: B
Width: 1.50"	Sleeve orie
Hole spacing: 1.50"	CW Mr OP

tole spacing:	1.50"		CW Mr Q	, '	
dge margin:	0.75"		σ Ο '	er:	
Naterial:	2024 1851		- r	or Dia.:	
Naterial gauge:	0.250"		0 ' rion:		
orface Treatment:	Shot Peen	_			
astener:	HiLok (Prot HD)				

2. Hole Preparation

4. Fatigue Conditions

2-6-73

Nominal hol	le size: 3/8" Ream, Install F	
Process:	Ream, Install F	astener
Fastener Inst	allation Torque:	220-240 In/lbs

Net stress:	JU KNI
Test load:	8500 lbs
Load ratio:	(R) = 0.1
Test Frequency:	5000/minute
Test Laboratory:_	Materials
Test Engineer:	D. Reese
Test Machine:	Vibrophore (36 kip)

2024	
Reamed Hilok	
30KS1	

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-1	1	. 3735	. 3737	+.0002	1 45	696	
	2	.3735	. 3735	NET	25		
- 2	1	. 3735	. 3735	NET	35	56 5	
	2	. 3735	. 3735	NET	30		
	1	.3735	.3735	NET	30	127	
-3	2	. 3740	. 3735	0005	25		<u>'</u>

TEST N	IUMBER:	3A 1a	
	_		

	EVALUEIONI	\/AIIIE .	-
NOMINAL	EXPANSION	AVE:	

GENERAL 1831 CONDITIONS

Specimen Description	
Zero load transfer, 2 Configuration:	hole, no CSK Fig. 2
Width:	1,50"
Hole spacing:	1.50"
Edge margin:	0.75"
Material:	2024 1851
Material gauge:	0.250"
Surface Teachments	Shot Peen

DATE:	2-6-73	
-------	--------	--

CW Process	
Sleeve typ	•:
Sleeve this	ckr AB
Sleeve	16 1
CM.	P .
× 6	`. toper:
_ 1 _idr	el Major Dia.:
rication O	•

2. Hole Preparation

Nominal	hole size: 3/8"
Process	Ream, Install Fastener
Fastener	Installation Torque - 220/240 In/II

Hilok (Prot HD)

2024	
Reamed Hilok	
30ksi	

4. Fatigue Conditions

Net stress:	30ksi
Test load:	8500 lbs
Load ratio: (R)	= 0.1
Test Frequency:	5000/minute
Test Laboratory:	Materials
Test Engineer:	D. Reese
Test Machine:	Vibrophore (36Kip)

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-10	,	.3735	.3735	NET	45	237	Head
"	2	. 3735	.3735	NET	-		
-11	1	.3740	. 3740	NET	40	205	Head
- "	2	.3745	. 3740	-0005			
	1						
-	2]	

TEST NUMBER:	3A 2

GENERAL TEST CONDITIONS

DATE: ____2-6-73

1. Specimen Description

Zero load transfer,	
Configuration:	Fig. 2
Width:	1.50"
Hole spacing:	1.50"
Edge margin:	0.75"
Material:	2024 T 851
Material gauge:	0.250"
Surface Treatment:	Shot Peen
Fostener:	Hilok (Prot HD)

3. CW Process

Sleeve Sleeve	thickness.	_
Sleeve CW M		_
<u> </u>	A P per:	
NO	ition:	_

2. Hole Preparation

4. Fatigue Conditions

Nominal	hole size:	3/ 8 "		
Process:	Ream	Install F	astenar	
Fostener	Installation	Torque:	220-240	in/1

	2024	_
(Reamed Hillok	
	25ksi	

Net stress:	25ksi
Test load:	7000 lbs
Load ratio: $(R) = 0$. 1
Test Frequency:	5000/minute
Test Laboratory:	Materials
Test Engineers	D. Reese
Test Machine:	Vibrophore (36Kip)

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-4	1	.3740	. 3735	- .0005	25	404	
	2	. 3745	. 3735	001	20	104	
-5	1	. 3745	. 3735	001	15	684	
	2	. 3745	. 3735	001	15		,
_	1						
	2						

TEST	NUMBER:	3A 3

NICHARLAL	EVBANISIONI	VALUE.	-
NOWINAL	EXPANSION	AWFOE:	

GENERAL TEST CONDITIONS

DATE: 2-6-73

1. Specimen Description

Zero load transfer, Configuration:	
Width:	1.50"
Hole spacing:	1 . 50"
Edge margin:	0.75"
Material:	2024 T 851
Material gauge:	0.250"
Surface Treatment:	Shot Feen
Fastener:	Hilok (Prot HD)

3. CW Process

Sleeve Sleeve Sleeve	type: thickner	CAP	JE -
CM ,	'bh.		
101	apei. "A arel Majo		
אורכם	rion:		

2. Hole Preparation

Nominal	hole size:	3 /8"		
Process:	Ream,	Install Fa	stener	
	Installation			in/lb

2024	
Reamed Hilok	
3.5ksi	

4. Patigue Conditions

35 ksi
9950 1bs
0.1
5000/minute
Materials
D. Reese
Vibrophore (36Kip)

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
	1	.3740	.3740	NET	20	82	C 4 E
-6	2	. 3745	. 3740	NET	20		
	1	. 3745	. 3735	001	20	79	
-7	2	.3740	. 3735	0005	20]	burnishing under head
	1						
	2						

TEST N	NUMBER: 3A 4
NOMINAL E)	XPANSION VALUE:
GENERAL TEST CONDITIONS	DATE: 2-6-73
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no C Configuration: Fig 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: Hilok (Prof	Sleeve thickner. Sleeve art. CW N P P per: arel Major Dia.:
2. Hole Preparation Nominal hole size: 3/8" Process: Rean, Install Fastener Fastener Installation Torque: 22 2024 Reamed Hilok 40 ksi	A. Fatigue Conditions Net stress: 40 ksi Test load: 11,400 lbs Load ratio: (R) = 0.1 Test Frequency: 5 00/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36Kip)

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Foilure (Thousands)	Origin of Failure and Remarks
-8	1	.3740	. 3735	0005	60	52	
	2	.3740	. 3735	~ .0005	70		
-9	1	. 3745	.3736	05.9	20	49	
	2	, 3745	. 3 735	001	20		burnishing fretting under head & washer
-	1						
	2						

TEST NUMBER: 3A 5 (2024)

NOMINAL EXPANSION VALUE: 0.018" - 0.020"

DATE: _

GENERAL	TEST	COND	TIONS
---------	------	------	-------

١.

Specimen Description Zero load transfer, 2 hole, no CSK Fig. 2 Configuration: _ 1.50" Width: _ 1.50" Hole spacing: 0.75" Edga margin: _ 2024 T851 Material: _ 0.250" Material gauge: Shot Peen Surface Treatment:

3. CW Process

2-8-73

Sleeve type:

Sleeve thickness:

0.010"

Sleeve orientation:

W Mondrel:

ST 5300-CBM-12-O-N

W Mandrel Taper:

W Mandrel Major Dia.:

0.3738"

Lubrication:

Fel Pro 300 (on sleeve)

2. Hale Preparation

Fastener: __

Nominal hole size: 3/8"
Process: CW, Ream, Install Fastener
Fastener Installation Torque: 220-240 in/lbs

Hilok (Prot HD)

2024 C/W Hilok 30ksi

4. Fatigue Conditions

Net stress: 30 ksi

Test load: 8,500 lbs

Load ratio: (R) = 0.1

Test Frequency: 5000/minute

Test Laboratory: Materials

Test Engineer: D. Reese

Vibrophore (36Kip)

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Nei Fir Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-12	1	.3730	. 3737	. 0007	20	591	
	2	.3730	.3737	. 0007	20		nutside
	1	.3730	. 3735	. 0005	25	950	
-13	2	.3730	.3737	. 0007	30		nutside
-14	1	.3730	. 3736	. 0006	20	608	
	2	.3730	. 3737	. 0007	25		fretting undernut

TEST NUMBER: 3A5 (7175)

			-
NOMINAL	EXPANSION	VALUE:	

GENERA	AI TEST	COND	ITIONS
LOCINEXA	41 1531	LUIND	1110143

DATE: ____4-6-73

1. Specimen Description

Zero load transfer, 2 hole, no CSK

Configuration: Fig 2

Width: 1.50"

Hole spacing: 0.75"

Edge margin: 7175 T 736

Material: 0.250"

Surface Treatment: Shot Peen

Fastener: Hilok (Prot Head)

٠.	CW Process	140HE 0780	
	Sleeve t	уре:	۰ \

Sleeve thickness.	
Sleeve orier 1 C 1	
CW Mr _ p \	
Ch. 86, wes:	
ر ن Major Dia .:	
a 0 ation:	

2. Hole Preparation

4. Fatigue Conditions

Test Machine:_

Nominal	hole size:	3/8"_		
Process	Keam,	install ra	stener	
Fastener	Installation	Torque:	225-250	Tn/1

Net stress:	30 ksi
Test load:	8,550 lbs
Lond ratio: (R) =	= 0.1
Test Frequency:	5000/minute
Test Laboratory:_	
Test Englances	D. Reese

Vibrophore (36 Kip)

 7175	
Reamed Hilok	
30 ksi	/

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fostener Diameter (Inches)	Net Fit Between Fastener and Hale	Hole Finish (RHR) After Ream	Cycles to Foilure (Thousands)	Origin of Failure and Remarks
	1	. 3735	. 3735	0	35	359	head
-1	2	.3735	. 3735	0	-] 337	
	1	. 3735	. 3735	0	35	1,007	Heo
-2	2	. 3735	. 3735	0	-	1,007	,
-3	1	.3735	. 3735	0	40	253	
	2	.3735	. 3735	0	-		

TEST NUMBER: 3A 6 (2024)

NOMINAL EXPANSION VALUE: 0.018" - 0.026"

GENERAL TEST CONDITIONS

DATE: 2-8-73

1. Specimen Description

Zero load transfer, 2 hole, no CSK Configuration: . Fig. 2 1.50" Width: _ 1.50" Hole spacing: 0.75" Edge margin: 2024 T 851 Material: _ 0.250" Material gauge: Shot Peen Surface Treatment: Hilok (Prot Head) Fastener: _

3. CW Process

Sleeve type: Axial Split

Sleeve thickness: 0.010"

Sleeve orientation: 0°

CW Mandrel: ST 5300-CBM-12-0-N

CW Mandrel Taper: 0.045"/"

CW Mandrel Major Dia.: 0.3738"

Lubrication: Fel Pro 300 (on sleeve)

2. Hole Preparation

Nominal hole size: 3/8"

Process: /W, Ream, InstallFastener
Fastener Installation Torque: 220-240 in/lbs

	2024	
(C/W Hilok	
	25 ksi	

4. Fatigue Conditions

Net stress: 25 ksi

Test load: 7,000 lbs

Load ratio: (R) = 0.1

Test Frequency: 5000/minute

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Vibrophore (36 Kip)

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Foilure (Thousands)	Orlgin of Failure and Remarks
-15	1	. 3730	. 3736	. 0006	25	7,779	
	2	.3730	. 3735	. 0005	30		No Failure
-16	1	. 3730	. 3738	. 0008	25	8,323	
	2	.3730	. 3738	. 0008	25		,
	1						
	2						

TEST NUMBER: 3A 6 (7175)

IAMIMON	EXPANSION	VALUE.	.019"

GENERAL TEST CONDITIONS

DATE: 4-6-73

1. Specimen Description

Zero load transfer, 2	! hole, no CSK
Configuration:	Fig. 2
Width:	1.50"
Hole spacing:	1.50"
Edge margin:	0.75"
Material: 7175 T	736
Moterial gauge:	0.250"
Surface Treatment:	Shot Peen
Fastener:	Hilok (Prot Head)

3. CW Process

Sleeve type:	Axial Split
Sleeve thickness:_	0.010"
Sleeve orientation:	0°
CW Mandrel:	0.045"/"
CW Mandrel Major Lubrication: Fel	Dia.: Pro 300 (on sleeve)

2. Hole Preparation

Nominal hale size: 3/8"
Process: C W, Ream, Install Fastener
Installation Tarque - 225-250 in/1bs

7175 CW Hilok 30 ksi

4. Fatigue Conditions

INDICITORS * :	ksi
Test load:	,450 lbs
Load ratio: (R)	0.1
Test Fraguency:	000/minute
Test Laboratory:	viarerials
Test Engineer:	D. Reese
Test Machine: Vib	rophore (36 Kip)

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-4	1	.3740	. 3740	0	40	613	head
	2	. 3740	. 3740	0	-	513	, l
-5	1	. 3735	. 3735	0	35	523	head
	2	. 3735	. 3735	0	-		'
-6	1	. 373 5	. 3735	0	40	293	head
	2	. 3735	.3735	0	-		'

TEST NUMBER: 3 A 7

	NOMINAL EXPANSIO	NV.	'ALUE:
 GE1	VERAL TEST CONDITIONS	DA	ATE: 2-8-73
١.	Specimen Description	3.	CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Fig 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: Hilok (Prot. Head)		Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CV/ Mandrel: ST 5300-C8M-12 -0-N CW/ Mandrel Taper: 0.045 "/" CW/ Mandrel Major Dia.: 0.3738" Labrication: Fel Pro 300 (on sleeve)
2,	Nominal hole size: 3/8" Process: C/W, Ream, Install Fastener Fastener Installation Torque: 220-240 in,		Fatigue Conditions **Table Stress: 35 ksi **Test load: 9,900 lbs **Test load: (R) = 0,1 **Test Frequency: 5000/minute **Test Lauratory: Materials
	C/W Hilok 35 ksi		Institugineers D. Reese Tast Macrities Vibrophore (36 Kip)

Specimen No. R623079	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finisa (REIR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-17	1	.3730	. 3737	. 0007	25	311	
	2	.3730	. 3736	. 0006	30	31,	Nut Side
-18	1	. 3730	. 3738	. 0008	20	387	
	2	3730	.3738	. 0008	25	30.	Head Side
	1						
	2						

TEST NUMBER: 3 A 8

NOMINAL EXPANSION VALUE: 0.018" - 0.020"

GENERAL TEST CONDITIONS

DATE: 2-8-73

1. Specimen Description

Zero load transfer,	`
Configuration:	
Width:	1,50"
Hole spacing:	
Edge margin:	0.75"
Material: 2024 T	851
Material gouge:	0,250"
Surface Treatment:_	Shot Peen
Fastener:	Hilok (Prot Head)

3. CW Process

Sleeve type: Axial Split
Sleeve thickness: 0.010"
Sleeve orientation: 00
CW Mandrel: 5T 5300-CBM-12 -0-N
CW Mandrel Taper: 0.045"/"
CW Mandrel Major Dig.: 0.3738"
CW Mandrel Major Dia.: 0.3738" Lubrication: Fel Pro 300 (on sleeve)

2. Hole Preparation

Nominal hole size: 3/8" Process: C/W, Ream, Install Fastener Fastener Installation Torque: 220-240 in/1bs

2024	
C/W Hilok	
40 ksi	_ /

4. Fatigue Conditions

Net stress:	40 ksi
Test load:	11,350 lbs
Load ratio:	(R) = 0.1
Test Frequency:	5000/minute
Test Laboratory	<u> Materials</u>
Test Engineer:_	D. Reese
Test Machine:_	Vibrophore (36 Kip)

Speeding0,500.	Hole No.	Hole Diameter (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hale Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-19	1	. 37 30	. 3735	. 0005	25	161	
	2	.3730	. 3735	. 0005	20		Head Side
-20	1	. 3730	. 3736	. 0006	25	149	
	2	.3730	. 3735	. 0005	30		Nut Side
	1						
	2						

TEST NUMBER:_	3 A -9 a
MINAL EXPANSION	N VALUE:

	TEST NUMBER	: <u>3 A - 7 d</u>
	NOMINAL EXPANSI	ON VALUE:
GENERA	L TEST CONDITIONS	DATE: 2-13-73
1. <u>S</u> p	ecimen Description	3. CW Process
	Zero load transfer, 2 hale, no CSK Configuration:Fig 2 Width:1.50" Hole spacing:1.50" Edge margin:0.75" Material:2024 T851 Material:0.250" Surface Treatment:Shot Peen Fastener:Taperlok (Prot Head)	CM , b b contains
2. H	ole Preparation	4. Fatigue Conditions
	Nominal hole size: 3/8" Process: Ream, Install Fastener Fastener Installation Torque: 220-240 i	Net stress: 30 ksi Test load: 8,400 lbs n/lbs Load retlo: (R) = 0.1 Test Frequency: 5000/minute

Prot. Head T/L 30 ksi

Net stress:	30 ksi
Test load:	8,400 lbs
Load ratios	(R) = 0.1
Test Frequency:	5000/minute
Tes: Laboratory	Materials
Test Engineer:	D. Reese
Test Machine:_	Vibrophore (36 Kip)

Specimen No. R623079	Hole No.	Head Protrusion (Inches) After Keam	Fostener Diameter (inches)	Net Fit Between Fastener and Hale	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
	1	. 232	-		30	94	
-23	2	. 228	-		-		Nut Side
	1	. 229	-		35	6,086	
-24	2	. 230	-		-	10,000	Head Side
-25	1	231	-		30	2,662	
	2	. 230					Head Side

TEST NUMBER	3A 9b

			NOMINAL	EXPANSION					
GENE	RAL TI	est conditio	NS.		DATE:_	3-6-7	3		
1.	1. Specimen Description				3. CW Process				
2.	Zero load transfer, 2 hole, no CSK Configuration: Width: Hole spacing: Edge margin: Material: Surface Treatment: Fig. 2 1.50" 1.50" 2.75" Material: 2024 T851 Material: Surface Treatment: Taperlok (Prot. H.				3. CW Process Sleeve type: Sleeve thickness. Sleeve orier CW Mr CW R Major Dia.: leadi 4. Fatigue Conditions				
	P	Pro. H	, install taste	ner 220-240 in 4	bs	Test location Test From Test Location	ad:(R atio:(R equency: _ boratory: _ cineer:	30 ksi 9,450 lbs = 0.1 5000/minute Materials D. Reese Vibrophore (36 Kip)	
Specimen No.	Hole No.	Head Protrusion (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fostener and Hole	Hole Finish (RHR) After Regin	Torque (in/lbs)	Cycles to Failure (Thousands)	Origin of Failure and Remarks	
	1	.224			55	225	1,236		
-35	2	.237			-	225	1,230		
	1								
	2								
									

	TEST NUMBER	R:3A-10
	NOMINAL EXPANS	ION VALUE:
GEN	NERAL TEST CONDITIONS	DATE: 2-13-73
1.	Specimen Description	3. CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Width: 1.50" Hole spacing: 0.75" Material: 2024 T 851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: Taperlok (Prot. H	Sleeve type: Sleeve thickness: Sleeve orien' CW Mar P P I I I Major Dia.: Major Dia.: Head)
2.	Hole Preparation	4. Fatigue Conditions
	Nominal hole size: 3/8" Process: Ream, Install Fastener Fast :ner Installation Torque: 220-240 2024 Prot. Head T/L	Net stress: 25 ksi Test load: 7,000 lbs in/lbs Load ratio: (R) = 0.1 Test Frequency: 5000/Minute Test Laboratory: Materials Test Foolness: D. Reese

Specimen No.	Hole No.	Head Protrusion (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-26	1	. 23 0	-		30	10.075	
-20	2	. 231			-	10,075	No Failure
	1	. 225	-		30	1,594	
-27	2	. 231	-		-		•
	1	.241	-	-	45	10,164	
-22	2	240	-	-	-		No Failure

Vibrophore (36 Kip)

Test Machine:_

TEST	NUMBER:	3A -11	
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NOMINAL EXPANSION VALUE:	NOMINAL	EXPANSION	VALUE:	
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GENERAL TEST CONDITIONS

DATE: 2-13-73

1. Specimen Description

Ē

- Zero load transfer, 2 hale, no CSK Fig. 2 Configuration: __ 1.50" Width: _ 1.50" Hole spacing:_ 0.75" Edge margin: _ 2024 T 851 Material: _ 0.250" Material gauge: ___ Shot Peen Surface Treatment:___ Taperlok (Prot. Head) Fastener: __
- Sleeve type:

 Sleeve thick
 Sleeve hick
 Sleeve AP

 CW
 AP

 Igper:

 Idrel Major Dia.:

2. Hale Preparation

4. Fatigue Conditions

Nominal hole size: 3/8"

Process: Ream, Install Fastener
Fastener Installation Torque: 220-240 in/lbs

 2024	
Prot. Head T/L	
25 ksi	

Net stress:	35 ksi
Test load:	9,800 lbs
Load ratio:	(R) = 0.1
Test Frequency:	5000/minute
Test Laboratory:	Materials
Test Engineer:	D. Reese
Test Machine:_	Vibrophore (36 Kip)

Specimen No. R623079	Hole No.	Head Protrusion (Inches) After Ream	Fastener Diameter (Inches)	Net fit Between Fastener and Hole	Hole Finish (RHR) After Reom	Cycles to Failure (Thousands)	Origin of Failure and Remarks
-28	1	. 230			25	328	
	2	. 231			-		Headside Failure
-29	1	. 232			30	369	
727	2	. 230			-		Headside Failure
_	1						
	2					l <u></u>	

Section 1. The section of the sectio

TEST	NUMBER:	3A-12
,	1 TO IT DE IT.	

			NOMINA	EXPANSION	VALUE:		
ĢEN	ERAL T	EST CONDITION	ONS		DATE: 2-13	-73	
1.	Specia	men Descriptio	n	• ;	3. CW Process		ale.
	C W H E A A S	ero load transiconfiguration: Vidth: lole spacing: dge margin: Aaterial: Aaterial gauge wrfuce Treame astener:	Fig 2 1 .50" 1 .50" 0 .75" 2024 T 851 . 0 .250" ent: Shot Pe		Sleeve Sleeve Sleeve	AP 1ap	er:
2.	, Hole I	Frep aratio n			4. Fatigue Cor	ndition s	
	P	Prot.	om, Install Fa	stener 220-240 in/1b	Test lo S Load ro Test Fr Test Lo Test Er	atio: equency: _ aboratory: . aineer:	11,250 lbs R) = 0.1
Specimen No. R623079	Ho(& No.	Head Protrusion (Inches) After Rejum	Fastener Diameter (Inches)	Net Fit Between Fostener and Hole	Hole Finish (RHR) After Ream	Cycles to Foilure (Thousands)	Origin of Failure and Remarks
-3'	, ,	. 234	-		25	237	
	,	233	_		-		Headside Failure

30

50

156

Spec. Overloaded No Data

Headside Failure

-31

-36

. 232

230

. 234

. 234

TEST NUMBER:	3A 13
IF 2 I 4 O IN DEV!	

NICHAINIAL	EXPANSION	VALUE.	-
NOMINAL	EXPANSION	VALUE: _	

GENERAL TEST CONDITIONS

1. Specimen Description

Configuration:	Fig. 2
Width:	1.50"
Hole spacing:	1.50"
Edge margin:	0.75"
Material: 2	024 T 851
Material gauge:	
Surface Treatment:	
Fastener:	Taperlok (100º He

3.	CW Process	6. *
	Sleeve Sleeve	thick (AB
	Sleeve CW	
	. b	Y Taper:
		andrel Major Dia.:

2. Hole Preparation

4. Fatigue Conditions

Nominal	hole size:	3/8"	
Process:	_ Ream,	Install F	astener
Fastener	Installation	Torque:	225-240 in/lbs

	2024	
(100° Head T/L	
	30 ksi	

Net stress:	30 ksi
Test load:	8,475 lbs
Load ratio:	(R) = 0.1
Test Frequency:	5000/minute
Test Laboratory:	Materials
Test Engineer:	D. Reese
Test Machine:	∨ibrophore (36 Kip)

Specimen No. R623079	Hole No.	Head Protrusion (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Foilure (Thousands)	Origin of Failure and Remarks
-32	1	. 201	-		30	147	
-32	2	. 190	-		-		1
22	1	. 2 07	-		30	264	
-33	2	. 206	-		-	204	}
	1	204	-]	30	196	
-34	2	202	-		-	1,70	

	TEST NUMBER:_	3M 14		
	NOMINAL EXPANSIO	N VALUE: _		
GENERAL TEST CONDITION	15	DATE:	3-9-73	

1. Specimen Description

Zero load transfer	, 2 hole, no CSK Fig. 2
Configuration:	1.50"
Hole spacing:	1.50"
Edan marnins	0.75"
Material:	2024 T 851
Material gauge:	0.250"
Surface Treatment	. Shot Peen
Fastener:	Taperlok (Flush Hea

3.	CW	Process

/ Process			
Sleeve typ	oe:	V P	
Sleeve th	ick 🔨	,	
Sleeve o	` ^ ` -		
CM V	8 ×		
ر, ا	`iaper:_		
. 1	rel Major D)ia,:	_
1.1	on:		_
, , , , , , , , , , , , , , , , , , , ,		· ·	

2. Hole Preparation

Nominal hole size: 3/8" Process: Ream, Install Fastener				

		_
/	2024	-)
1	100° Head T/L	1
	25 ksi	_ノ

4. Fatigue Conditions

Net stress:	25 ksi
Test load:	7000 lbs
Load ratio:	(R) = 0.1
Test Frequency:_	5000/minute
Test Laboratory:	Materials
Test Engineer:	D. Reese
Took Machines	Vibrophore (36 Kip)

Specimen No. R623079	Hole No.	Head Protrusion (Inches) After Ream	Fastener Diameter (Inches)	Net Fit Between Fastener and Hole	Hole Finish (RHR) After Ream	Cycles to Failure (Thausands)	Origin of Failure and Remarks
-21	1	. 204			45	612	
-2'	2	. 205			-	012	
	1	. 206			40	441	
-23	2	. 207			-	661	
	1						
	2						

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T1-6A1-4V.	reamed, Hi-Lok	70 ksi	
\	_	/	•

					70 ksi	1
		1EST_3T1	Í	SPECIMEN 623078 DATE 9/19/73		
SPECIMEN DESCRIPTION	PTION	COLDWORK PROCESS		HOLE PREPARATION	FATIGUE CONDITIONS	,
contamodras	Fig. 2	Interletence		Nominal hole size (in) 0.375	Max net stress (ksi)	2
Material	Ti-6Al-4V (annealed)	Sleeve type		Process Ream	Max test load (kip)	ଯ
Width (in)	1.50	Steeve thickness (in.)			Load ratio (RI	19 8
Hole specing	05.1	Steeve orientation			Test frequency	9000
Edge mergin Iin)	0.75	Nandrel material		FASTENER INSTALLATION	Test laboratory	Materia
Material gage (in.)	0.250	Mandrel taper fin fin f		Type Hi-Lok prot hd	Test engineer	0 8
Surface treatment	Shot peen	Mandrel max diameter (in)	lin)	Fit (in.) Net to 0.0005 clearance	Test machine	Vibrag

Vibraphore 36-kip

240 to 250

Torque (in Ib)

Lubrication

4000 cpm

Origin of failure	and remarks					F.							
Cycles	faiture	90,000				83,000				78,000			
Fastener size fin l	Fit	Net	Net			0.0005	0.0005			Net	Net		
Fastener	Diameter	0.3740	0.3740			0.3745	0.3745			0.3740	0.3740		
Caldwork expansion (in)	Retained												
Cok	Actual												
â	After	40	;			50	1			9	-	1	
Hole finish (RHR)	Atter												
Ĭ	Before coldwork												
_	After	0.3740	0.3740			0.3750	0.3750			0 3740	0 3740		
Hole diameter (in)	After												
PH.	Before												
	4 Or	-	2	2	4	-	2	2	4	~	2	3	4
	destinen destinen	-				,				۳,			

PHASE II - TASK 3-BASIC FILLED-HOLE DATA

Ti-6AI-4V. reamed Hi-Lok. 75 ksi

TEST_312__ SPECIMEN_623079_DATE__9/19/73

SNO	75	- 22	0.1	Materials	Ciprosition of the Control of the Co	O. Reex	Vibraphore 36-kip	
FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Les frequency	Test laboratory	Test engineer	Test machine	
	0.375	Ream				Hi-Lok prot hd	Net to 0.0005 clearance.	-240 to 260
HOLE PREPARATION	Nominal hole size lim?	Process			FASTENER INSTALLATION	Type	Fig (in.)	Torque (in ib)
COLDWORK PROCESS	Interference	Steeve type	Sireve thickness (in)	Slegge prientation	Mandel material	Mandrel taper (in /in)	Mandkel max diameter (m.)	contractor of
NO	F.g. 2	Ti 6A! 4V (annealed)	1.50	1.50	0.75	0.250	Shot peen	
NOITHING N DESCRIPTION		Material	Width ten)	Hoir spacing (in.)	Edge margin iin i	Material gage (in.)	Surface treatment	

Origin of failure	and remarks	•	P P P				DH L		{			
Cycia	favore	47,000				52,000						
Fasienes size (m.)	Fit	Nei	Net			Net	Zet					
Fastener	Diameter	0.3740	0 3740			0.3740	0.3740					
Coldwork expansion (-n-)	Reconect											
Colc	Actual									Ì		
· .	Alter	20	i			45	,			_	_	
HOLE fraish (RHA)	After											
Ī	Betore coldwork											
_	After	9.3740	0.3740			0 3740	0.3740					
Mote diameter (n.)	Afred COLfamith											
¥a;	Before coldwark											
		-	~	~	4	-	2	 7	-	2	0	4
	188 to	•										

PHASE II -TASK 3 - BASIC FILLED HOLE DATA

DATE 9/19/73

313

1631

Ti 6AI 4V reamed, Hi-Lok 65 ksi

36-kip Vibraphore 4000 cpm Materials D. Reese 19.3 0.1 જ FATIGUE CONDITIONS Max test load (kip) Max net stress (ks+) Load ratio (R) Test frequency Test laboratory Test machine Test engineer Net to 0.0005 clearance 240 th 250 0.375 FASTENER INSTALLATION Nominal hole size (in) HOLE PREPARATION Torque (in 1b) Process Type SPECIMEN 623079 ũ Mandret max diameter (in) Mandrel taper (in /in.) Steeve thickness (in) COLDWORK PROCESS Sleeve or motation Mandrel material Steeve Lype Lubrication Interference Ti-6Al-4V (annealed) Shot peen 0.250 1.50 50 0.75 SPECIMEN DESCRIPTION Surface treatment Material gage (in) Edge mergin (in) Configuration Hole spacing Width in Mater ist

					Т				T	_			7
Origin of failure	and remarks			¥					P.	<u>}</u>			
Cycles	failure	199,000				92,000							
Fastener size (m.)	٩.	Net	Set			Net	Net					 -	
Fastener	Diameter	0.3740	0.3740			0.3740	0.3740						
Coldwork expansion (in.)	Retained												
lo) Coli	Actual												
â	After	8	,			45	_ '				_	_	4
Hole finish (RHR)	Alter coldwork												
Ĭ	Before colthwork			1									
-	Atter	0.3740	0 3740			0 3740	0.3740						
Hole diameter (in)	After												
, ž	Betor												
	r or	-	2	3	4	-	~	m	4	-	2	~	4
	Specimen	Į,				,							

PHASE II - TASK 3 - BASIC FILLED HOLE DATA

Ti-6AI-4V, reamed, Hi-Lok, 60 ksi

EST 374 _ SPECIMEN 623079 DATE 9/19/73

S	909	17.7	0.1	4C00 cpm	Materials	D. Reese	36-Vibraphore	
FATIGUE CONDITIONS	Max net stress (%s)	Max test load (Kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	0.375	Ream			NOI	Hi-Lok prot hd	Net to 0.0005 clearance	240 to 250
HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Fig (in) Net to	Torque (in:Ih)
COLDWORK PROCESS	Interference	Sleeve type	Sleeve thickness (in)	Streve orientation	Mansifet material	Mandret taper fin /m l	Mandrel max diameter (in)	Lubrication
TION	Fig. 2	T · 6Al-4V (annealed)	1.50	1.50	0.75	0.250	Surface treatment Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material	Width tin	Hole spacing	Edge margin (in.)	Material gage lin J 0.250	Surface treatment	

Property (sales	and remerks	{	DH L		}	}	H []		}				
Cycles	to fanure	246,000				139,000							
Fastener size tin)	ī	Net	Net			Net	Net						
Fastener	Озамене	0.3740	0.3740			0.3740	0.3740						
Coldwork expension (in)	Ret aned												
ນedva ເຕວ	Actual												
IR)	After	40	1			45	1						
Hole finish (RHR)	After coldwork												
ĭ	Before coldwork												
-	After	0.3740	0.3740			0.3740	0.3740						
Hole diameter (in)	Atter												
Ĭ	Betare												
į	0u	-	7	3	4	-	2	m	7	-	2	3	4
Specimen	00	æ				6		:					

PHASE 11-TASK 3- BASIC FILLED.HOLE DATA

∕	Ti-6Al-4V sta,	reamed, Hi-Lok,	70 ksi	
	1			

DATE 9/19/73

SPECIMEN 623079

1651_375__

A STATE OF THE STA

	70	20.4	0.1	4000 срт	Materials	D. Reese	36-kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip) 20.4	Load ratio (R)	Test frequency	Test lationatory	Test engineer.	nce Test machine	
	0.375	Ream			Z	Hi Lok, prot hd	Net to 0.0005 clearnce Test machine	2407250
HOLE PREPARATION	Nominal hole size (in.)	Proces.			FASTENER INSTALLATION	Тург	F	
ı								
COLDWORK PROCESS	Interference	Slenup 1yDE	Sleeve thickness (in)	Slerve of entation	Mandret material	Mandrel taper (in /in)	Mandrel max diameter (in.)	
	Fig. 2	Ti 6Al-4V (sta)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material	Width (10.)	HOP SINGERING	Edge margin (in)	Material gage (in) 0.250	Surface treatment Shot peen	

Origin of fature	and remarks	[]*	24			•	PH			→	ОН		}
Cycles	to faiture	65,000				74,000				82,000			
Fastener size (in)	Fit	Net	Net			Net	Net			Net	Net		
Fastener	Diameter	0,3740	0.3740			0.3740	0.3740			0.3740	03740		
Coldwork expansion in)	Retained												
Cole	Actual												
£3	Atter	52	-			20	,			25	!		
Hole finish (RHR)	Atter												
Ĭ	Before coldwork												
-	After	0 3740	0 3740			0.3740	0.3470			0 3740	0.3740		
Hole diameter (m.)	After cordoork												
Ĭ.	Before colchwork												
Š		-	2	3	Þ	-	2	3	4	-	- 2	3	4
Sperimen	no or	1 Sta				. Z sta				S sta			

PHASE II - TASK 3- BASIC FILLED HOLE DATA

Ti-6Al-4V stoa, reamed, Hi-Lok, 70 ksi

DATE 9/19/73 SPECIMEN 623079 TEST_3T6

SPECIMEN DESCRIPTION	TION	COLDWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS	
Configuration	Fig. 2	Interference	-	Nominal hole size (in.)	0.375	Max net stress (ksi)	70
Material	Ti-6Al-4V (stoa)	Sterve type		Process	Ream	Max test load (kip)	8
Width (in)	1.50	Sleave thickness (in)				Load ratio (R)	0.1
Hole spacing	1.50	Sleuve orientation.				Test frequency	4000 cnm
Edge margin (in)	0.75	Mandrel material		FASTEMER INSTALLATION	2	fest laboratory	Materials
Material gage (in) Shot peen	Shot peen	Mandrel taper (in fin I		Type	Hi Lok, prot hd	Test engineer	D. Reese
Surface treatment		Mandrel max diameter (in)		Fir Net to 0	Net to 0.0005 clearance	Test machine	Vibraphores
		Lubrication		Torque (in Ib)	240.250		

Overland of factors	and remarks	1	¥ [-	F						7
Cycles	to faiture	82,000				74,000				000'69			
fattimer size lin)	٤	0.0005	0.0005			Net	Net			Net	Net		
Fastime	Diameter	0.3745	0.3745			0.3740	0.3740			0.3740	0.3740		
Coldwork expansion (in)	Retained												
Corc	Actuat												
-	After	8	:			8	I			35	ı		
Hole Linish (RHR)	Afrec												
Ĭ	Before coldwork												
-	After	0.3750	0.3750			0.3740	03740			03740	03740		
Hole (hameter fin.)	After												
ĭ	By fare colubrant												
i o		-	2	3	4		,	3	4	-	2	3	4
Sperimen	g g	4 stoa				5 stoa				.6 stoa			

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PHASE II -TASK 3-BASIC FILLED-HOLE DATA

Ti-6Al-6V-2Sn, reamed, Hi-Lok, 70 ksi

100 mg 10

. . . .

FATIGUE CONDITIONS 0.375 Ream SPECIMEN 623079 DATE 9/19/73 Nominal hole size (iii) HOLE PREPARATION Process 1657 377 COLDWORK PROCESS Interference 7-6AI-6V-2Sn (annealed)Steeve type SPECIMEN DESCRIPTION

36-kip Vibraphore 4000 cpm D. Reese Materials 202 Max net stress (ksi) Max test load (kip) Load ratio (R) Test frequency Test lationatory Test machine Test engineer Hi-Lok prothd Net to 0.0005 clearance

FASTENER INSTALLATION

Streve thickness (in)

3 2 0.75

Configuration

Swive orientation Mandrel material 1,00 Ē 240.250 Torque (in 1b) Lubricition

Mandrel max diameter (in.) Mandrel taper (in 'in)

Surface treatment Shot peen Material gage (in) 0.250

Edge mergin (in)

Hole specing Width In Meres is

Origin of failure	and remarks	-	w ₂			•	ciw			{	ciw		
Cycles	failure	53,000				43,000				26,000			
Fastener size (in)	Fit	0.0005	0 0005			90000	0 0005			Ner	Net		
Fastener	Diameter	0 3740	0.3740			0 3740	0.3740			03740	03740		
Coldwark expension (in i	Retained												
Cold	Actual												
œ	After ream										!		
Hole finish (RHR)	After		 										
Ĭ	Betore												
-	After	0.3745	0 3745			0 3745	0 3745			0 3740	0 3740		
Hole dameter fin i	After												
Но	B-fore col:twork												
Hoir		-	2	~	4	-	2	3	4	_	7	3	4
Specimen	6 2	1 662				2.662				3 662			

Ti-6Al-6V-2Sn sta, reamed, Hi-Lok, 70 ksi

PHASE II-TASK 3- BASIC FILLED:HOLE DATA

DATE 9/19/73 SPECIMEN 623079 TEST 3T8

36 kip Vibraphore 4000 cpm D. Reese Materials 2 FATIGUE CONDITIONS Max test load (kip) Max net stress thail Test laboratory Load ratio (R) Test frequency Test machine Test engineer Net to 0.0005 clearance Hi-Lok, prot hd 24.250 0.375 Ream FASTENER INSTALLATION Nominal hole size lin l. HOLE PHEPARATION Torque (in 1b) Process Type F.T Wandrel max diameter (in).. Mandrel taper (in /in) Steeve thickness fin I COLDWORK PROCESS Sleeve arrentation Mandrel malerial Sieeve type Interference T: 6AI-6V-2Sn (sta) Surface treatment Shot pern Material gage (in.). 0.250 3 1.50 Edge margin (in.) 0.75 SPECIMEN DESCRIPTION Configuration Hole spacing Width In 1

Material

Lubricition

	Organ of failure		{	_	PH L						PH	$\overline{}$				•	# [}		
	Cycles 10	\$ 10.0°	000						48 000						000 82						
Factorine Cold Pin 1		ű	į		Net				å	Met	Net				01000	200	0.0005				1
Factories		Diameter	0.2340	0.57	0.3740				0770	0.3/40	03740				0.020	0.3740	0.3740				
Coldwork	expansion to 1	Retained															_				
Š	uedxa	Actual										_						+			-
	ĉ.	After		8	'			_		<u>ਲ</u>	1	'		+		8		+			\downarrow
	Hole linish (RHR)	Alter																		-	-
	Ī	Before	COLCOROL												_						
		r Ha	E.	0.3740		0.3740				0.3740	;	0.3740				03750		0.3/40	_		
	Hole diameter (in)	Atter	coldwork																		
	Ť	Betore	cotdwork																		
		F OF			-	2	,,	,	7		_	2	<u> </u>	m	4		-	7	، إ	, i	4
	L	Specimen dash no		653	4.005				l		-5-662					100	700.0				

PHASE II -TASK 3. BASIC FILLED HOLE DATA

T₁ 6A1 6V 2Sn stoe. reamed, Hr.Lok, 70 kss

	ONS	20	20 (di	0.1	4000 cpm		D. Reese	36 kgp Vibraphore		
	FATIGUE CONDITIONS	Max not sterns (hvi)	May test load (kip) 20	Load ratio (R)	Less feequent v	Victoriational Inc.)	A object 14	Test mar him		
SPECIMEN 623079 0ATE 9/19/73	HOLLE PARATION	0.375	Ream	איני אפון		NOI VILLE INVITATION	Asienes	Net to 0 0005 clearance	Torque (m. 16)	
319 SPECIMEN 62		GOLDWORK PROCESS	toperference	Miles at 1 Miles	Shawe thickness (in 1	Sleaves as a confidence	Manded material	Manuel taper for on t	Mandad max chamble (m.)	
		SPECIMEN DESCRIPTION COLOMO	2	Ti-6AI 6V-2Sn (stoel)	1.50	1.50	Edge margin (ii) 1 0.75		l was	•

	Oxigin of failure	and remarks		(}													()	<u> </u>		ı	
	Cycla	2	•	8	0.00	_				-	52,000	+		_			51,000	+			<u> </u>			
	f delicione size fell l		Ξ.		ž	Net			i -	-	ž		ž Z	ļ_			Ž		Ne:	-				
	f astribut		Ocument		03740	0.3740			i i		0.3740		03740				0 3740	5	0.3740	-				
 	Continuor	expansion (in	Hertaurid														-			! ! ! ! !		!	-	
	3	A CHARLES	Actival							_	-		_		_	! !	-	_	<u> </u>		_	-		
			Alla	III PA	7,5				-		1	52	-	+	_	<u> </u>	-	8	<u> </u>	+			$\frac{1}{1}$	
		Hole linish (MMM)	Alter	coldwarh				! !								\ 	; 			-	_			1
!		₹	Before	Colcheork															-					
	<u> </u>	_	1		1	0 3740	0 3740	1		_		0.3740		0.3740	 	+		0 3740	2	0 3740	! ! 			
		Hole diameter (in)		Cylchwork														-				!	<u> </u>	
		Hol		Betore												-					+		_	
			Hole	ġ.		-	,	,	2		4	1	<u></u>	2	,	٣	٩	-	_	,	•	٣	₌	·
			Specimen	2		7.662	eois					0 5.63	100 eo						9.662					

PHASE II - TASK 3. BASIC FILLED-HOLE DATA

Fi 6AL4V CAN, Hi Lok, 70 ksi

\	25	70	20.4	0.1	4000 cpm	Materials	D Reexe	36 kip Vibraphore	
	FATIGUE CONDITIONS	Max met strins (ker)	Max test total (kip) 20.4	Load ratio (R)	Anterthay ser [Test laboratory	ferniger ter	Test machine	
7,73		0.375	Ream, C/W, ream			V C	Hi Lok, prot hd	Net to 0.0005 clearance	240 250
SPF CIMEN 623079 DATE 9/20/73	HOLE PREPARATION	Morning bate size (n)	Process			FASTENER INSTALLATION	Type	F., Net	Torque (as th)
TEST. 3T10 SPECIMEN.		0.019	Split	0.010	0	AISI9260 Steel	0.045	") 0353	Fel Pro 300
1631.	COLDWORK PROCESS	loter ferenege	Slever type	Sterve the kness for I	Sleeve orientation	Manifed material	Manifel taper for /m ?	Mandret max diameter (m.) 0.353	Lubber study
		Fig. 2	Ti-6Al-4V (annealed)	1.50	1 50	0.75	0.250	Shot peen	
	SPECIMEN DE SCRIPTION	Configuration	Material	Width tin 1	Hafe spacing	Edge marger (m.)	Material gage (in.) - 0.250	Surface treatment Shot pren	

Oxide of behave	andremaks		CW FF			-	C.W HG				C.W		
Cyclis	fature	1,830,000	j			347,000				000'869			
Fastener seze (m.)	=	0.0005	0.0005		; ;	0 000 0	0 0000	! !	!	0 0005	0.0005		: -
Fasterie	Dapmene	0.3740	0.3740	! ! ! ! _	i : !	03740	03/40	i i i	 	0.3740	03740	i	! — ! !
Cotilwai k engansadai (m.)	Retained	0600 0	0600 0		 	600000	0600.0			0.0000	06000		:
Col	Actual	0.0185	0.0184	!	! ! !	0.0185	0 0 1 85			0.0185	0.0185	!	! !
ę.	Atter	25	! ! !	!	<u> </u>	8	! 		 	32	! ! !	 	
Hole funsh (RMK)	Atter	25		!	 	2	 	i.		25	i ! •	•	! !
¥	Betour coldwark	90	i !	: : !	i i i	45	i 	!	 	33	! ! !	! ! 	
-	Ather	0 3745	0.3745			0 3745	0 3745	i i		0.3745	0.3745		
Hole dametis (m.)	After	5£9£ 0	0 3635			0 3635	0.3635		 	0.3635	0 3635	 ! 	
Ma	Before co cheark	0.3545	0.3545			0.3545	0 3545 0 3635			0.3545	0 3545		
į	ā	-	2	3	4	-	2	3	4	-	2	8	न
Specimen	Ou Ou	10				11				12			

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PHASE II - TASK 3 - BASIC FILLED HOLE DAIA

Ti 6A! 4V. C/W, Hi Lok, 65 ksi

36-kip Vityraphore 4000 cpm Materials D Reese 힐 FATIGUE CONDITIONS Max net stress (ks.) Max test load (kip) Test frequency Lest laboratory Load ratio (R) Test engineer Test machine Ream, C/W, ream Hi Lok, prothd Net to 0.0005 clearance 240.250 0.375 SPECIMEN 623079 DATE 9/20/73 FASTENER INSTALLATION Normanal hove size fin i MOLE PREPARATION Torque (in lb) Process Type Ē AISI 9260 Steel Fel Pro 300 0.045 0.019 0.010 Mandrel max diameter (in.) 0.353 Split TEST_3711 Mandrel taper (in /in) Sieeve thickness (m.) COLDWORK PROCESS Sleeve brientation Mandrel material Interference Sherve Lyne Ti-6Al-4V (annealed) Surface treatment Shot peen Material gags Inn) 0.250 Fig.2 1.50 1.50 0.75 SPECIMEN DESCRIPTION Edge margin fin.: Configuration Hole spacing Width In) Material

Lubrication

Origin of faiture	and remarks	-				← ({				
Çycl#	failure	1,333,000				2,273,000							
Fastener size (in)	Ē	0.000.0	0.0005			0.0005	0.0005						
Fastener	Diameter	0.3740	0.3740			0.3740	0.3740						
Coldwork expansion (in)	Hetained	06000	0600.0			06000	0600.0						
Cold	Actual	0.0185	0.0184			0.0185	0.0185						
_	After	8				35	\ \					_	
Hole finish (RHR)	After	20	 			50							
£	Before	30				40	-						
	Afrer	0.3745	0.3635			0.3745	0.3745						
Hole shameter (in.)	After	0.3635	0.3635			0.3635	0 3635						
HOI	Before	0.3545	0 3545			0.3545 0.3635	0.3545						
	Hote	-		~	4	-	,	,	,	-	2	7	4
	Specimen dash no	13	2			14							

The second secon

PHASE II-TASK3- BASIC FILLED HOLE DATA

T. 6AI.4V, C/W, Hi.Lok, 75 ksi

		TEST	TEST_3T12_SPECIMEN	SPECIMEN 623079 DATE 9/20/73	<u>ස</u> ්	
SPECIMEN DESCRIPTION		COLOWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS
Configuration	Fig. 2	lither ference	0.019	Nominal Bote 5,725 Lin 3	0.375	Max net stress (ker)
Material	Tr 6AL4V (annealed)	Sierve Type	Split	Process	Ream, C/W, ream	Max test load (ktp)
Width (in)	1.50	Steeve thickness (in)	0.010			Load ratio (R)
Hole spacing	1 50	Sheve or entation	0			List frequency
Edge margin (in.) 0.75	0 75	Manifrel material	AISI 9260 steel	FASTENER INSTALLATION		Fist laboratory
Material gage (in.) 0.250	0.250	Mandrel taper (in /in)	0.045	Typy	Hi-Lok, prot hd	Frst engineer

36 kip Vibraphore

Test machine

Net to 0.0005 Clearance 240-250

Torque ten 1b)

Fel Pro 300

Lubrication

F.1

Mandrel max thameter (m.) 0.353

Surface treatment Shot peen

5000 cpm Materials D. Reese

0

75 2

Orono of Jahre	and remarks		CN			-	C.W Hd						7
Cycles	facture	203,000				159,000							
Fasterier size tin 1	1.	0.0005	0.0005			0 0005	0.0005					;	
Fasteur	Uiameter	0.3740	03740	{ ; ;		0.3740	0.3740	 					
Coldwork expansion (in)	Rutained	0.0000	0.0000			0.0000	0.0090						
Cole	Actual	0.0185	0.0185			0.0185	0.0185						
₽	After	35				32							
Hole finish (RHR)	After	8	,		1	20							
344	Before cordwork	55				S	,						
0	Afrer	0.3745	0.3745			0 3745	0.3745						
Hole diameter (m.)	After	0.3635	0.3635			0.3635	0.3635					_	
140	Before col.h.ork	0.3545	0.3545			0.3545	0.3545						
Hote	ş	-	2	3	4	-	2	3	4	-	2	3	4
Specimen	geg or	-15				91							

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Ti-6A1-4V, C/W, Hi-Lok, 80 ksi

	য	88	37.0	6.5.3	0.1	4000 cpm	Moterials	9		36-kip Viorapriore		
	FATIGUE CONDITIONS	sea cot stress (kSi)		Max test load (kip) -	Load ratio (R)	Test frequency	V)O(R)O(a)	G	Test engineer	Test machine		
523079 DATE 9/20//3		HOLE PREPARATION	Nominal hole size (in)	Ream, C/W, ream	Process			FASTENEP INSTALLATION	Hi-Lok, prothd	Met 10 0 0005 clearance	240.250	Lorder time to
3713 SPECIMEN 623079 DATE 9/20//3	lesi de				Split	s (m.)	0	AISI 9260 steel	•	(in /in)	Mandrel max diameter (in) 0.353	Fel Pro 300
		COL DIMORK PROCESS	200	Interference	(annealed) Sleeve type	Siege thickness (in.)		Shewe of the control	Mandrei material	Mandrel taper (in /in)	1	noticisation a
			SPECIMEN DESCRIPTION	Fig. 2	Ti-6Al-4V (annealed)	Material	Width (in)	Hole spacing	Edge matern (in)	0.250	Shot peen	פתנופרב ווכפוניים

_		_						Т	_	_	_	_	_	Т	_	_	=	_	7	1		
Origin of failure	and remerks		*	() ()						() PH					\	L			\ 			
Ç	2		000 001	190,000				_	000	137,000					-			_				
Fastener size (in)		Ţ.	1	00000	0.0005	-		<u> </u>		0.0005	0.0005	1		_				+	-			
Fastener		Diameter		0.3740	0.3740					0.3740	0.3740							\ \ +		_		
1,04	(u.) uc	Retained	1	06000	0000	0.003				06000	000	0.000				- -	-				-	
Cotdwork	expansion (.n.)	Actual		0.0185	100	C810.0				0.095	3	C810.0					+			-	-	
	_	Alter	Egg	2,5	3	1				٤	₹	1				-	\downarrow	_	-	 	4	
	Hole finish (RHR)	After	coldwark	,	3	i					25	1							-	-		
	P	Before	colidwork		ଞ	'					æ		.									
			- Fe3:	+	0.3745	0 274E	200				0 3745		0.3745					-		-		
	Holy diameter (in)		Atter	COLUMNIE	0.3635		0.3635			,	0.3635		0.3635									
	HOH		. —	coldwork	0.3545		0.3545				0.35.45	2222	0 3545								1	
	1	 1	Ş		1	-	2	,	,	4		_	2	,	,	4	-	-	2	~	, -	4
			5 S]:	- 						8-			_							

PHASE II -TASK 3- BASIC FILLED HOLE DATA

<u> </u>	Ti-6Al-4V sta.	70 ksi	\ /
			•

9/27/73
DATE
PECIMEN 623079
TEST_3714 S

		2	20 1	0.1	4000 cpm	Materials	D. Reese	36 kip Vibraphore	
	FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	,	0.375	Ream, C/W, ream			NCI	Hi-Lok, prot hd)	Net to 0.0005 Clearance	240-250
	HOLE PREPARATION	Normal bole size (in)	Process			FASTENER INSTALLATION	Type	Fit Net	Torque (in tb)
		0.019	Split	0.010	0	AISI 9260 steet	0.045	0.353	Fel Pro 300
1	COLDWORK PROCESS	Interference	Sleeve Lype	Sheve thickness (in)	Sleeve orientation	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (in.), 0.353	Lubric shon
	7110 <i>x</i>	Fig. 2	Ti-6Al-4V (sta)	1.50	1.56	0.75	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Material	Width In 1	Hole spacing	Edge margin (in)	Material Dage In 1	Surface treatment	

Origin of failure	andremarks	Hd	300			- F	7			- S			
Cycles	fa.lure	509,000				468,000				545,000)	
Fastener size tris l	6 .d	0.0005	0 0005			0.0005	0.0005			0.0005	0.0005		
f astener	Diameter	0.3740	0.3740			0.3740	03740			0.3740	0.3740		
Colifwork expansion (in.)	Refained	0.000.0	0 0000			0.0085	0.0000			0.0000	0.0000		
Cold	Actual	0.0185	0.0185			0.0185	0.0185			0.0185	0 0185		
ء	After	\$	-			40	:			40			
Hole finish (RHR)	After	20	ı			20				52	١		
Î	Bafore coldwork	45				45	i			93			
_	After	0.3745	0.3745			0 3745	0.3745			0.3745	0 3745		
Hole thameter (in)	After	0.3635	0.3635			0.3630	0.3625			0.3635	0.3635		
HO	Before colcavork	0.3545	0.3545			5.3545	0.3454			0.3545	0.3545		
	Hole on	-	2	3	4	-	2	3	4	-	2	3	4
	dest. no	1				æ				6			

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	375 C.W. ream Hi-Lok. prot hd Hi-Lok. prot hd Hi-Lok. prot hd 1000 0 00005 1740 0 00005 1740 0 00005 1740 0 00005 1740 0 00005	A COLOR OF THE PERSON OF THE P
,	ATE 9/27/73 ATE 9/27/73 ATE 9/27/73 ATE 9/27/73 ATT 0000 Service (in) 0 Net to 0.000 Service (in) 0 Net to 0.000 Service (in) 0 Net to 0.000 Service (in) 0 Net to 0.000 Service (in) 0 Net to 0.000 Service (in) 0 Service (in) 0 Service (in) 0 Net to 0.000 Service (in) 0 Service (in)	n go generalization
	1	
1	115 SPECIMEN [115 SPECIMEN 6 0019 0.009 0.	
	PHASE 11 - TASK 3 - BASII PHASE 11 - TASK 3 - BASII TEST 3715 TEST 3715 TEST 3715 Sieeve type Sie	1
	Mole disment III Mole disment II Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment III Mole disment	
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PHASE II -TASK 3- BASIC FILLED HOLE DATA

Ti-6AI-6V-2Sn. C/W Hi-Lok, 70 ksi

TEST_3T16___ SPECIMEN__623079__DATE_9/27/73_

70 20.6	0.1 4000 cpm	Materials D. Reese	36-kip Vibraphore
FATIGUE CONDITIONS MAN net stress (bs.) Max test load (kip)	Load ratio (R) Test frequency	Test taboratory Test engineer	Test machine
0.375 Ream, C.W. ream		TION Hi-Lok prothd	Net to 0.0005 clearance 240 to 250
MOLF PREPARATION Nominal Pole size lin) Process		FASTENER INSTALLATION Type	Fit (in.) Torque (in. tb)
0.019 ·	0.010	AISI 9260 steel	10.353 Fel Pro 300
COLDWORK PROCESS Interference (in.)	Sieeve thickness (in)	Mantiset material	Mandre: max diameter (m)
Fig. 2	Width (in) 150	0.75	Shot peen
SPECIMEN DESCRIPTION Configuration Fig.	Material II Oct. Width (in)	Fage mergin (in)	Material gage (in). Surface treatment

Origin of fature	and remains	CW Hd	ф П	}		- ¥	₹ P		4	PH NO	更日]	
Cycles	fariate	530,000				487,000			-	195,000			
Fastener size Inn)		Net	Net		-	Zer	Net			Zet	Sea	+	
Fastener	Diameter	0.3740	0.3740			0.3740	0.3740			0.3740	0.3740		
Coldwork. expansion (in i	Retained	0.0080	0.0000			0 0000	0.0080			0.0085	0.0085		
Cold	Actual	0.0185	0.0185			0.0185	0.0185			0.0185	0.0185		
2	Alter	35	-			45				35	-	_	
Hole linish (RHR)	After	25				25	'			25	ı		
\$	Before	50				50	,			55			
	After	0.3740	0.3740			0,3740	0.3740			0.3740	0.3740		
Hole thameter (in)	After	0.3625	0.3625		Ĺ	0.3625	0.3625			0.3630	C.3630		
F	Before	0 25.45	0.3545			0.3545	0.3545			0.3545	0.3550		
	, 6. 5.	-	2	3	4	_	2	8	4	-	2	6	4
	Spetimen dash no	5	2			;	-			.1.	-		

	20 22 A 0.1 Materials D. Reexe 36-kip Vibraphore	
Ti.6AI.6V.2Sn sta, C/W Hi.Lok, 70 ksi	FATIGUE CONDITIONS Max net stress thail Max rest load (kip) Load ratio (R) Test frequency Test intensineer Test machine	
PHASEII -TASK 3- BASIC FILLED-HOLE DATA	Fig. 2	1

	Origin of felure			() P			}		¥ 3			-		•	P. P.			}	,	
	و در	t voice		143,000					98,000	_	-		_	-	110,000		-	-		
E actorior 51.70 (rd.)		ű.		Net	Net				Net		Net				Net	Ž		+		
John J		Diameter		03740	P 3740				0.3740		0.3740				0.3740	0.0140	0.3/40			
Colifmont	expannon tin l	Hetained	1	ì		ļ			0.0075		0.0080				0 0080	7	0.0185 0.0080			
8	ruedxa.	Actual		0.0185 0.0075	0.0185 0.0075	200			0.0185		0.0185				0.0185	1	0.0185			
		Atter		40					, i	3	•				40	-	1			
	Hole finish (RHA)	Atter	T IOMINO	52					,	ę	-				75		-		_	
	2	Botze	colchwork	45						20	1				Ş		'			
		Afre	ueau	0.3740		0.3740		_		0.3740	0.3740				0 27.40	2000	0.3740			
	Hole diameter (in.)	After	colidwork	0.35.0	2000	0.3620				0.3620	0,3625				3000	0.3023	0.3625			
	Ē	Bufore	_	2020	0.3383	0.3545				0.3545	0 3545					0.3545	0.3545			
		10 Pr		-		2	8	[3		2			67].		ć,	9	ļ.	4
		Specimen			E	_				14			_			-15				_

/		_	\
	Ti-6AI-6V 2Sn stoa,	C/W, Hi-Lok,	70 KSI
	ATAM BUILD HOLE DATA	PHASE II - TASK 3 - BASIC FILLED TOUR DATA	

	70 20 0.1 4000 cpm Materials D. Reese 36-kip Vibraphore
	FATIGUE CONDITIONS Man rest stees (1831) Load ratio (RI Test frequency Test frequency Test ecqueers Test ecqueers
DATE 9/20/73	HOLE PREPARATION Norm without wite fin 1 Process Ream, C.W. ream Nor test load ratio (RI) Fast Enqueries The targement of the fin 1 Tori decimal of the fin to 0.005 clearance Test machine to the fin that the fin to 0.005 clearance test machine to fin that the fine that the fin that the fin that the fin that the fin that the fin that the fine that the fin that the fin that the fin that the fin that the fin that the fin that the fin that the final that
TEST_3118 SPECIMEN 623079 DATE 9/20/73	1960 steel
TEST	COLDWORK PROCESS Interference (in.) Sieve type Sieve thu kness (in.) Sieve or entation Sieve or entation OSteve or entation Mandrel taper (in.) Cubb Cubricition Fel Pro
	SPECIMEN DESCRIPTION Configuration Material Width (in) Hole spacing Euge margin (iii) 0.250 Material gage (iii) Surface treatm (iii) Shot peen

						_	T	Г		_	_	 7		_	_ 		7	1
	Origin of failure	Surgaria Dug	•	CW Hd				4	CW Hd				•	7	3			
	(velsk	faiture	197,000						000.06		<u> </u>			147 000				
	Fastener size iii i	<u>.</u>	Nei	:	Nc1		_		Set	Z			+	Ne:	2		+	
,	Patrone	()eameter	3,23	5	0.3735				0.3735	3676.0	55,50			0.3735	22.50	26/5/		-
Superior of	(ui) cosuedxo	pauretile		Ţ	0.0085				0.0085		cann'c			0.0085		6800.0		
200	suedko	Actual	1000	0.0185	0.0185				0.0185		0.0185			0.0185		0.0185		
	-	Alter		45	1				20					45			_	
	Hole finish (RHR)	Atter		2					2		1			Ķ				
	Ĥ	Before	i Can	45	-				4	2				C	3	-		
		After	Elean	0.3735	0.3735				2000	0.3/33	0.3735			0 22.26	0.3/33	0.3735		
	Hole diameter (in.)	After	coldwork	0.3630	0.3630					0.3430	0.3630			3	0.3630	0.3630		
	HOF	Berore	coldwork	0.3545	0.3545					0.3545	0.3545				0.3545	0.3545		
		i S		_ _	2	~	,	4		-	2	3		. .	-	2	9	4
		Specimen dash no		1 16.662					17.662	stna				18 662	stoa			

And the second of the second of the second s

	70 20 0.1 4000 cpm Materials D. Ruese 36 k.p Vibraphore	
Ti 6Ai 4V prot hd, Taper Lok. 70 ksi	Mar net steer (ks) Mar text load (ktp) Load ratio (R) Text Hequency Text interactory Text cognorer Text machine	
PHASE II -TASK 3 - BASIC FILLED HOLE DATA TEST. 3119 - SPECIMEN 623079 DATE 10.1973	HOLE PREPABATION Normed hale were line) Process Process Ream Ream Frastener installation Type: Type	
PHASE ^{II} -T	COLDWORK PROCESS 1-sterference Steeve type Steeve type Steeve ore-induor Mandret material Mandret may diameter (in 1 -	•
	SPECIMEN DESUR PTION Configuration Ti 6AL4V (annealed) Width tim Width tim Hole spacing Especiation for 1.50 Material gage fin 1.50 Material gage fin 1.50 Surface treatment Shot peen	

Origin of failure	sagual pag	₹ + ₹	7	}	+	PH			4	Hd			
Cycles	tainre	367,000				000 689				5.323,000		-	
flastener size tim t	Fd	Class F	Class			Class F	Class F			Class F	Class F	- -	
f astroner	Distributor		!								!		
Caidwark expansion (in)	Refainers			-							-		
Series Con	Actual		 		-			1		-	-		
£	Alter	20	 		-+	25	-	-		15	- <u> </u> - 	-	_
Hole firish (RHR)	After										-		 -
Ĭ	Refore		! ! !									 -+	
-	Aller	0.240	0.240	-		0.240	0.240			0.230	0.230		
Hote diameter (in)	After											<u> </u> 	
£	Before									ļ Ļ			
	io S	-	5	3	4	_	2	m س	4	-	2	~	4
	Specimen dash no	5				5				2			

Tr. GAI.4V prot hd. Taper Lov. 75 ksi

PHASEII -TASK 3- BASIC FILLED HOLE DATA

TEST 3T20 SPECIMEN 623079 DATE 10 18/73

36-kip Vibraphore 4000 cpm Materials D. Reese 21.5 FATIGUE CONDITIONS Max Instituted (kip) Max net stress (ksi) Test lationatory Test frequency Load ratio (R) Test machine Test enginem Taper Lok, prothd F. (in.) Boeing Class F (0 187-0.289) 240.250 0375 Ream FASTENER INSTALLATION Normal habe size (m.) HOLE PREPARATION Torque for thi Proces 1 viv Mandrel max diameter (iii) Mandrel taper (in /in') Sheve thickness tin 1 COLDWORK PROCESS Sleeve prientation Mandrel material Lubrication Interference Sireve type Ti-6A1-4V (annealed) Shot peen 0.250 0.75 33 3 Fig. 2 SPEC:MEN DESCRIPTION Material gage (in) Edge margin lin l Surface treatment Configuration Hole spacing Width (in) Material

_					_	_	_	<u> </u>	_			_			1	_	_						
ender to co. O	and remarks		•	PI							P	١.				\ _ 							
	. 01	lature.		3,086,000						10 061 000				-							1		
Fasteries Sever Ser		-		Class F	,	C1055 F				- Lines F	Cinion .	Class F	_	+			-		 	+			
F BSt r Cart		Di pimetiri														-	\ \ \		-	-			
Courtmort	expansion fin i	Refaired								-					_	+			-	+			
Š _	enparis	Actual										_	1			-			+	-			
	_	Aftra	-	1	2		'		_		15		-		-	\downarrow		_	-	-			
	Hoir finish (RMR)	4114	cold work																1		-		
	Ē	Butor	roldwork										1		\ \ \ 								
			ניפיי		0.230		0.230				0.20	0.630	0.230			-1	-				+-		
	Hote diameter (in)		After															-		_			
	Ť		Before	CORONGIA													_						
		Hole	3		_	-	7		ا ز	4		-	2	1	e)	7	-	- -	c:	-	; 	4	
		Specimen	۶		3	77						.23			_			_					

Ť	\		69	19	0.1	4000 cpm	Materials	D. Reese	36-Kip Vibraphore		
Ti-6Al-4V, prot hd, Taper Lok, 65 ksi		FATIGUE CONDITIONS	Man net stress (ksi)	Max test load (kip)	Load latio (R)	Test frequency	Test lationatory	Test engineer	Test machine		
HOLE DATA	SPECIMEN 623079 DATE 10/18/73	HOI E PREPARATION	0.375	Ream	riotes.		CASTENER INSTALLATION	Taper Lok prof hd	Boeing class F (0.187.0.283)		
HASE II - TASK 3 - BASIC FILLED HOLE DATA	TECT 3121 SPECIMEN		COLDWORK PROCESS	Interference	Steeve type	Steeve thickness (in)	Steeve of entation	Mandrel material	Mendret taper (m./m.)	Mandret max diameter (in).	Lubrication
¥			ECIMEN DESCRIPTION CO	Configuration Fig. 2	Material Tr.6A1.4V (annealed)	Width lin 1	Hole specing	Edge margin in) 0.75	Material gage (in) 0.250	Surface treatment Shot peen	

\$11(m) to 00000	and remarks		*	- E				No failure	•	- 1				No failure								
1	<u>0</u>	failure		7,788,000						7,774,000				-	+							
Fastener size lin !		<u>.</u>		Class F	<u>'</u>	Class F			1	Class F		Class F		-							-	
Fastene		Diameter									-		ļ			_				-		
Cclidwork	expansion tin)	Retained						-		_						-		_	-	+	-	
કૅ	expan	Actual											-	1		-			-	+		
	Ē	After	ream	!	2		-		_	+	2	_	1	-		+	_	_	$\frac{1}{1}$	+		
	Hole finish (RHR)	After	columork												L							
	Î	Before	COIGMON																			
}			Lega.		0.230		0.240				0.230		0.235		+			+	_			
	Hote diameter (in)		After																			
	Į Į		Belore	CONCIONO		+											-			_	-	
		_	Ş		-	-	2	٦	, 	4		-	C1	,	,	4	-	-	2	-	+	-
		Specimen	S			-24			j			-25	L									

PHASE II - TASK 3 - BASIC FILLED-HOLE DATA

Ti-6AI-4V. prot hd, Taper Lok 60 ksi

Appendix 1 - 1 - 1 - 1 - 1 - 1 - 1

36-kip Vibraphore FATIGUE CONDITIONS Max test load (kip) Max net stress (ks.) Test laboratory Load ratio (R) Test frequency Test machine Test engineer Taper Lok prot hd Boeing class F (0.187-0.289) 240.250 0.375 Ream DATE 10/18/73 FASTENER INSTALLATION Nominal hole size (in J HOLE PREPARATION Process Fit[in.] SPECIMEN 623079 TEST 3722 Mandret max diameter Inn } Mandrel taper (in./in.) Sleeve thickness (in) COLDWORK PROCESS Steeve orientation Mandrel material Sleeve type Interference Ti-6At-4V (annealed) Shot peen 0.250 3 8 0.75 SPECIMEN DESCRIPTION Surface treatment Material gage (in) Edge margin (in) Hole spacing Material Width (in)

Torque (in. Ib)

Lubrication

4000 cpm Materials D. Reese

Origin of failure	and remarks	\ - \frac{1}{2}				¥			No failure				
Cycles	failure	300,000		<u>]</u> 		7,602,000			°Z				
Fasiener size (in)	Fit	Class F	Ctass F			Class F	Class F						
Fastener	Diameter												
Coldwork expansion (in)	Retained												
Cold	Actual												
R;	Alter	15	_			15	_			_	_		,
Hale finish (RHR)	After coldwark												
<u> </u>	Before												
_	After	0.230	0.188			0.230	0.230						
Hole diameter (in)	After												-
f	Before coldwork												
	No.	-	2	3	٠	-	2	6	4	-	2	٣	4
Gentle Service	gg Sc	.26				77.							

4V. per Lock			70	20	0.1	4000 cpm	Materials	D. Reese	36 -kip Vibraphore	
Ti-6A1-4V, flush hd, Taper Lock 70 ksi		FATIGUE CONDITIONS	Max nel stress (ksa)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	118/73		0.375	Ream			NO	Taper Lok, flush hd	Boeing class F (0 187 0 289)	240 250
HOLE DATA	SPECIMEN 623079 DATE 10/18/73	HOLE PREPARATION	Nominal bole size (in)	Process			FASTENER INSTALLATION	Type	Fa (in.)	Torque ton (b)
- BASIC FILLED	3723 SPECIMEN								("	
PHASE II -TASK 3- BASIC FILLED HOLE DATA	TEST	COLDWORK PROCESS	Interference	Sleeve type	Sleeve thuckness (in I	Steeve orientation	Mandrel material	Mandrel taper (in 'in)	Mandret max thameter (in)	Lubrication
-			Fig. 2	Ti-6Al-4V (annealed	1.50	1.50	0.075	0.250	Shot peen	
		SPECIMEN DESCRIPTION	Configuration	Material	Width (in)	Hole spacing	Edge margic (in)	Material gage (in)	Surface treatment	

Origin of failure	and remarks	{							{			
Cycles 1	TD: safe	1,146,000				240,000			370,000			
Fastener size (in)	F.1	Class F	Class F			Class F	Class F		Class F	Class F		
Fastener	Diameter											
Coldwork expansion (in)	Retained											
Colo	Actual											
£.	Atter	20	_			8	1		25	1		
Hole fraish (RHR)	After coldwork											
1 1	Before											
_	After											
Hote diameter (in)	After	0 206	0.201			0.201	0.202		0 200	0.217		
÷	Before											
	ۇ ۋ	-	2	m	Ą	,-	7	3	_	2	3	Ð
Specimen	dash on	82				82			8			

PHASE ILTASK 3- BASIC FILLED-HOLE DATA

TEST 3724 SPECIMEN 623079 DATE 10.19.73

flush hd, Taper Lok,

		75	21.5	0.1	4000 cpm	Materials	D. Reese	36-kip Vibraphore	
	FATIGUE CONDITIONS	Max net stress liksi	Mex test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
1	•	0.375	Ream			20	Paper Lok (flush hd)	Boeing Class F (0.187.0.289)	240.250
	HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Fit	Torque (in its)
	COLDWORK PROCESS	Interference	Steeve type	Sleeve thickness lin l	Sleeve or ientation	Mandrel material	Mandret taper (in lin)	Mandrel max diameter (in).	Lutinication
		Fig. 2	Ti-6Al-4V (annealed)	1.50	1.50	0.75	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Material	Width (in)	Hole spacing	Edge margin (in)	Material gage (in.), 0.250	Surface treatment	

Origin of failure	and remarks	}			}	}							
Cycles	to failure	372,000				000'66							
Fastiener size (in)	F.1	Class F	Class F			Class F	Class F						
Fastener	Diameter	:											
Colifwork expansion tin 1	Retained												
Cote	Actual												
	Atter	8	1			82	-						
Hole finish (RHR)	After												
¥	Before												
_	After												
Hole diameter (in)	After coldwork	0.202	0.208			0.1920	0.1930						
ų	Before coldwork												
a G		-	2	6	4	-	2	3	4	-	2	3	4
Spreimen	Sec.	31				-32							

Ti-6AI-4V, flush hd, Taper Lok, 65 ksi	FATIGUE CONDITIONS	Max net stress (ksi) 65	91 (gix) hard year and	Load (8) (R) 0.1	Test frequency	Test laboratory Materials				
SSIC		0.375	Configuration Fig. 2 Interference Configuration Ream	Ti-6Al-4V (annealed) Sieeve type	Width in i	Hole spacing	Edge margin (in) 0.75 Mandrel material Taper Lok, flush hd	Boeing Cla	Surface treatment Shot peen Mandrel max diameter (in 1	Lutarication Torque (in lib)

_				5	7	=)	7		(-			7						7		
	Origin of failure									<u></u>											
	Cycles	lailure		266,000					563 000	┙											
	Fastener size tin i	ī		Class F	Class F				2 286	2 (88)	Class F									 -	
,	F astener	Diameter																			
Coldmonk	expansion (in.)	Retained																			
100	Suedra	Actual						_		_			_								
	â	Atta	E T	2	,			_		52	-	:		-			+			-	\downarrow
	Hole timsh (RHR)	After	coldwork																		
	Ť	Before	coldwo'k															_			
		Air	Crear	0.214		0.206				0 197		0.198	_			_			-		
	Holy diameter (in.)	2012	Coldwork																		
	H		Coldwork															_			
		ž g	!]	-	2	٦	,	4		-	2	,	ກ	4	-	-	2		3	4
		Specimen	2	5	3						4										

PHASE II-TASK 3- BASIC FILLED HOLE VALUES

TEST 3126 SPECIMEN 623079 DATE 10/19/73

Ti.6Al-4V, flush hd, Taper Lok, 60 ksi

1. 1. E

36 kip Vibraphore 4000 cpm Materials O. Reese May net sires (bot) 60 FATIGUE CONDITIONS Max test load (kip) Load ratio (R) Test faboratory Test frequency Test engineer Test machine TaperiLok, flush hd Boeing Class F (0.187-0.289) 240.250 0.375 Ream FASTENER INSTALLATION Nominal hole size (in.) HOLE PREPARATION Torque (in Iti) Process TVDC ž Mandret max diameter (in.) Mandrel taper (in fin) Steeve thickness (in) COLDWORK PROCESS Sleeve Orients 10n. Manifrel material Ti-SAL-4V (annealed) Sleeve type Interference Cultrication Shot peen 0.250 1.50 55 0.75 SPECIMEN DESCRIPTION Surface treatment Material gage (in) Edge margin (in) Configuration Hole spacing Width (in) Naterial

Origin of failure	and remarks	{				{			}	{			
Cycles	fo (ailure	1,092,000				2,602,000							
Fastener size (m.)	\$ -1	Class F	Class F			Class F	Class F						
Fasterw	Diameter												
Contwork expansion in 1	Retained												
Coli	Actual												
Ri	After	20	,			20	,						
Hole finish (AHR)	After												
Ĭ	Refore coldwork												
	Alter	0.215	0.202			0 204	0.204						
Hote diameter (m.)	After												
£	Before												
1		-	2	3	4	-	2	٣	Þ	-	2	3	4
Specunen	da or	35				36							

PHASE II -TASK 3 - BASIC FILLED-HOLE VALUES 300 M, Ream, Filled, 100 KSI

	100	28.1	0.1	4200 com	Materials	D. Beese	100 kip Vibraphore	
	FATIGUE CONDITIONS	Max test load (hip) 28.1	Load ratio [R]	Test frequency	Test laboratory	Test engineer	Test machine	
SPECIMEN623079DATEB/14/73_	HOLE PREPARATION	Tholy size for 1	Process			Type Hi Lok, prot hd (steel)	F.i. (in.) 0.0005-0.0010_clearance_	Torque (m. lb) 240
TEST3S1SPECIMEN	COI DWORK PROCESS	Interletings .	Sleave LyDR	Stewer Phickness (in)	Sixew: prientation.	Mandrei material	Mandrel taper (in /in	- phicaling
	SPECIMEN DESCHIPTION COLDWG	Ganfiguration Fig. 2 Interfe	Material 300 M steel (270-300 ksi) Sierus	Width (in) 150 Sierre	Hole spacing 1.50 Sheem		Material gauge (in.) 0.250 Mand	

_				_	T	_	7				1		7	T	_	_		7	
			}	1	\bigoplus	+			}	1	F) 							
	Origin of faithfre			P			-	-	- 3	Ď									
	O			-						-	•	+							
_	Cycles	failure		112,000						237.000									
	Fastenel size lin 3	Ē	5	3	1000				+00005	2000	+0.0005							-	
	Fastenei	Diameter	3000	0.37.33	0.3735				0 2240	0.3740	0.3740								
	Coldwerk expansion (in)	Retained													_			1	
•	3 6	Actual						_			L								
		Atte		10	1					2					-	1			
	Hale finish (RHR)	Alter																	
	ĭ	Before	1000											İ					
	•	Alla	Line of	0.3745	0 3745	2				0.3745		0.3745							
	Hole diameter (in.)	After	coldwork	•			1												
	io I	Bufaer	catchwork																-
		101 31		-		7	٣		4	-	- -	2	m		-7	-	2	~	4
		Spe: men dish no		•	-					٦									

PHASE II -TASK3 - BASIC FILLED HOLE VALUES 300 M, Ream, Filled, 105 KSI

TEST 352 SPECIMEN 623079 DATE 8214.73.

	105	29.2	0.1	4200 срп	Materials	D. Reese	100-kip Vibraphore		
FATIGUE CONDITIONS	Max net street livel 105	29.2	Chadratio (B)	Anadobasi Net	The lattoratory	Test engineer	Test machine		
RETION	3/8	Nominal hole size the limit of	Keam install installs:		NOTA LIATING COLUMN	Hill ok, prof hd (steel)			ifol .
HOLE PREPARATION		Nominal ho	Process	1	1	t ASTENEN	Aut.	TIL 2	Torque (in :fb)
		-		'		:	:	n).	-
	COLDWORK PROCESS	tuterference	Sterver Pyth	Siegae thickness fin E	Steave orientation	Nandrel material	Mandrel taper in in I	Mangert max diameter find)	
	NO	Fig. 2	300 M steel (270-300 ksi)	1.50	1.50	0.75	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Maire a 300 M	Width 10.3	Photograph	Edge margin lin)	Material geg. (m.) 0.250	Suchar treatment Shot peen	

-		_	T	5				}			_		<u> </u>	{			{	_						
	Origin of failure and remarks			-	£ 1			No. Company	Lalye Gowin Com	-	PH	1					}							
	500	13 miles			000'.6						125 000	_					-			_				
(01) 9411 1101				+0.0015		+0.00.0				0100	20.01	+0.0010		_			-				 -			
	L'ASSENTA	0.00		0776.0	2	0.3740	\ 	{		0000	0.37.35	0.3735								! 	-			
Coldwork	Expansion (ir.)	:	H. Garrell									-		_	+		 -			\ \ \ \	\ -\			
į	vuentra		Actual									-	_	_	1		1			1				
	ā		FEST	1	5	;	1			1	2	1	. [-	$\frac{1}{1}$	_	-	-		+		-	$\left\{ \right.$	
	Hole finish (RHR)		Coldwork								_	-					-		-	1		-		
	ĭ		Sefore -				į																	
			Afrer		0.3755	100	0.3/30				0.0745	0.3/45	0.3745	1		_			}		_	+		i
	Hole diameter (in)		A!I	CDISMON N								,												
	140		Before	colthwork																		\downarrow		
		101			-	-	~	(*)	`	۵	1	-	ļ	, l	~	1	.	-	.	~	<u>-</u>	, <u> </u>	4	-
		Decimen	2 6	. —	,	7						4												

PHASE II - TASK 3 - BASIC FILLED HOLE YALUES.

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300 M, Ream, Filled, 110 KSI

TEST. 353 SPECIMEN 623079 DATE 8/14/73

FATISUE CONDITIONS	Max out stress taxe: 110	Nav rest load (kp) 31	Loadrang (R) 0.1	Tist frequency 4200 cpm	first laboratory Materials	Text engineer D Reese	Test machine 100 kip Vibraphore	1
HOLE PREPARATION	Nominal historie (in) 3/8	Process Ream, install fastener			FASTENER INSTALLATION	Type Hi-Lok, prot hd (steel)	Fit (in.) 0.0005.0.0010 clearance	Torque (iii lh) 240
				ı	1	1	1 1 1 0	1
COLDWORK PROCESS	Interference	Sterve Type	Slewe this kness (in)	Skive orientation	Mandkel material	Mandrel taper in in]	Mandret max diameter (in)	Lubrication
SPECIMEN DESCRIPTION	Configuration Fig 2	Material 300 M steel (270-300 ksi)	Wether Lead	Hole statemen	Edde margin (i.i.) 0.75	Material gage lin) 0,250	Surface treatment Shot peen	

Origin of failure	and remarks	-			Large fatigue growth zones	H ₆	1			_	¥		
Cyclms	10 5	36 000	200.0			000	90,000			000 00	95,000		
Fastener size tin.)	ů.	10 0005	+0.0005			+0.0010	+0.0010			+0.0005	+0 0002		
Fastener	Diameter	0.3740	0.3740			0 3735	0.3735			0.3740	0.3740		
Colitiwark expansion (in I	Retained												
Cole	Actual												
ie.	Atter	02	,			10	,			10	,		
Hale Trash (RMR)	After												
Ĭ	Before contwork												
_	After	0.3745	0.3745			0.3745	0.3745			0.3745	0.3745		
Hole diameter (in)	After coldwork												
î	Before												
Î	â	-	2	3	4	-	2	12	4	-	~	m	t,
Sperimen	∯ag g	-5				9-							

PHASE II -TASK 3 - BASIC FILLED-HOLE VALUES

300 M, Ream, Filled, 115 KSI

TEST_ 354 SPECIMEN 623079 CATE 8/14/73

•	Load ratio (R) Test tequency Test enquees Test enquees Test enquees	RINSTALLA His in.J 0.0		Sieree thuckness (in.) Sieree orentation Manifest material Manifest taper (in.i.n.) Manifest max diameter (in.)	Width (in) 1.50 Hole spacing 1.50 Edge marger (in) 0.75 Surface treatment Shot peen
Materials D. Reexe	Test lattoratury	FASTENER INSTALLATION Typ: Hi-Lok, grot hd (steel)		Mandref material Mandref taper (m. l.m.)	
Materials	Test lationalury	+ ASTENER INSTALLATION	1	Mandet material	
4200 cpm	A readinguit &		1	Slucve ofventation	1.50
0.1	Luatratio (R)		1	Sierve (hickness (-n.)	
32.5	Max fest load flup)	Process Ream, install fastener		Sleeve type	300 M steel (270.300 ksi)
115	"Max met stries 18 (1)	Nominal hole use (in) 3/8		Interference	Fig. 2
ŝ	FATIGUE CONDITIONS	HOLE PREPARATION		COLDWORK PROCESS	SPECIMEN DESIGNIPTION

Success of Success	and remarks	-	₽ [}	_	\$ []			{		
Cycles	to fedure	300 04	90,04				000714					
Fasterner size (in)	F. et	+0.0005	+0.0005			+0.0010	+0.0010					
Fasterpe	Diameter	0.3740	0.3740			0.3735	0.3735				} ! !	
Caldwork expension (in)	Retained											
Cole	Actual											
÷	Adrer	2	 			0	١					
Hole finish (RHR)	After coldwork											
Ť	Before contwork											
-	Atter	0.3745	0.3745			0.3745	0.3745					
Hole diameter (in)	After											
Ho	Bulare roldwork								_			
i o	g	-	2	3	4	-	2	3	9	-	 6	7
Specimen	75°	8				6-						

PHASE II -TASK 3- BASIC FILLED-HOLE VALUES

300 M C/W, net fit Hi Lok, 100 ksi

TEST 355 SPECIMEN 623079 DATE 8/27/73

Ş	100	28	0.1	4000 cpm	Materials	D. Reese	100-kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ks)	Max test tous (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	0.375	Ream, C/W, ream			N _C	Hi-Lok prothd	Net to 0.0005 clearance	240.250
HOLE PREPARATION	Naminal hole size (in.)	Process			Carbide IBAC 5972) FASTENER INSTALLATION	Type	F.r (in.) Net to	Torque (m. 1b)
	0.023	Push, no sleeve			Carbide IBAC 5972)	0.045	0.358	Fel Pro 300
COLDWORK PROCESS	Interference (in.)	Sleeve type	Sleeve thickness (in)	Sleeve of lentation.	Mandrel material	Mandrel taper (in fin.)	Mandrel max diameter (in). 0.358	o o o transfer I
71.0N		300 M steel (270-300 ksi)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material 300	Width (m.)	Hole spacing (in.) 1.50	Edge margin (in.)	Material gage (in)	Surface treatment	

Yigo of falure	and remarks	{-		<u>7</u> 1		{		=) 	}	{		7	
		•	A CA]	No failure				
Cycles	to faiture	673,000				8,300,000							
Fastener size (in)	۴.,۱	0.0005	0.0005			0.0005	0.0005						
Fastener	Diameter	0.3735	0.3735			0.3730	0.3730						
Caldwork expansion (in)	Retained	,	1			ļ	1						
Cali	Actual	ì	ļ			-	i						
H)	After	20	_			20	-:						
Hale traish (RHR)	Afrer	ı	-			1	1						
Ĭ	Bafore colifeerk	-	ı			-	-						
-	After	0 3740	0.3740			0.3775	0.3735						
Hole diameter (in)	After Colismork	1	ı			ſ	1						
Ť	Before colowork		1			1	1						
9	5	-	2	3	4	-	2	3	4	-	2	3	4
Specimen	ξξ ος	.10				1-							

PHASE II -TASK3 - BASIC FILLED HOLE VALUES

DATE 8/27/73 SPECIMEN 623079 1£57 3S6

300 M C/W, net fit, Hi-Lok, 105 ksi

-

The second secon

HOLE PREPARATION

0.375

COLDWORK PROCESS

SPECIMEN DESCRIPTION

Configuration

interference (in.)

Sleeve Type

300 M steel (270-300 ksi)

1.50 1.50 0.75

Width (in)

Nominal hole size hin } Process Push, no sleeve 0.0235

FASTENER INSTALLATION Carbide (BAC 5972)

Sleeve thicknoss (in.)

Sleeve or ientation Mandrel material

Hole spacing(in.)

Net to 0.0005 clearance Torque (in.ith) Fir (in.) Type

240.250

Fel Pro 300

Lubricition

Mandrel max diameter (in), 0.358

Shot peen 0.250

Surface treatment

Material gage (in.).

Edge margin (•n.)

0.045

Mandrel taper (in /in)

100 kip Vibraphore 4000 cpm Materials O. Reese Max net stress (ksz) 105 FATIGUE CONDITIONS Max test load (kip) Test laboratory Test frequency Load ratio (R) Test engineer Test machine Hi-Lok prot hd Ream, C/W, ream

Orign of failure	and remarks	- F				→ X				{			
Cvcles	to fancre	462,000				4,203,000							
Fastroqu'ssze (.n.)	r u	Net	Net			žė.	Net						
Factorer	Diameter	0.3735	0.3735		•	0.3735	0.3735						
Coldwork expansion (in)	Retained	1	i			_	١						
Cole	Actual	ı	-			:	i						
æ	After	30	,			25	ı						
Hole linish (RHA)	After	1	-			ı	_						
Ĭ	Before coldwork	l	_			-	-						
_	Atter	0.3735	0.3735			0.3735	0.3735						
Hole diameter (in.)	After	-	1			;	;						
f	Before	1				-	_						
3		-	2	3	4	-	2	3	4	-	2	3	4
Specimen	de or	.12				.13							

Marie Andrews Andrew

PHASE II -TASK3 - BASIC FILLED-HOLE VALUES 300 M, C/W, Filled, 110 KSI, 0.045 Taper, 0.023-0.0245 Interference

	110	10	4200 cpm	Materials	D Reese	100 kip Vioragatore	
	FORTIGUE CONDITIONS May net stress (Not)	Man fort load (kip) Load ratio (R)	Tops frequency	Test lationalmy	Test engineer	Test matchine	
ATE 8/17/73	3/8	C.W. ream, install fastener		STALLATION	Hi-Lok, prot hd (steel)	Net to 0.0005 clearance	161)
SPECIMEN_623079 DATE_8/17/73	HOLE PREPARATION Named have see in t	S E S E		: ASTENER INSTALLATION	7	f 11 (10)	Torque in ibi
387	0.0230/0.0245	Push (no sleeve)		Carbide (BAC 5972)	0.045	0.358	Fel Pro in hole and
1657	COLOWDRK PROCESS	Steroe type	Sterese that kness (in)		Manter maintel	Mandre Laper (m. 11) 0.358	Lubrication
	SPECIMEN DESCRIPTION	Contiguration 300 M steel (270-300 ksi)	W.dth (in) 1.50	Hole spacing	Euge margin (in) 0.75	Material gage Lin I U.250	Surface treatment

	Origin of fature			Co.				Large Lones		₹.	PL					7000		•				
	Cycle	1000		000 191							382,000						25,000	7.7.			ļ -	
-		.,		90000	1 6	3				0.0005		0000 C					Set	5,0005	1		-	
	Pastener Sura Per	1	The Table	0.3735		0.3/35	_			0.3740		0.3740					0.3740	0 3740	: !			
	, ur) ucrasedna	_	Helia															-				
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1			Actual	0.0745		0.0245				0.600	0.020	0220	200				0.0230	100	0.0230		-	
		1	t f	٤	2	-				:	61	_	<u>'</u>	_	+		15	!	1	 -	+	
	Hole tonsh (RHH)		Atter													_			_			
	Î		Betorn						_													
		1	Atlen		0.3740	0.3740					0.3745		0.3745					0.3740	0 3745			
	Hote diameter (m)		After																			
	HOF		Helore	icay Io.	_																	
		i i			-	,	,	۳		4	-	- -	2		٣	,	,	-	,	7	3	4
		Specimen	de 5		41.						:	cl -						9	2			

300 M C/W, net fit, Hi-Lok 115 ksi

PHASE II -TASK 3- BASIC FILLED-HOLE VALUES

100-kip Vibraphore 4000 cpm D. Reese Materials Max net stress iksil 115 8 FATIGUE CONDITIONS Max test load (kip) Load ratio (R) Test frequency Test laboratory Net to 0.0050 clearance Test machine Test engineer Ream, C.W. ream Hi-Lok prof hd 240.250 0.375 DATE 8/27/73 Carbide (BAC 2972) FASTENER INSTALLATION Nominal hole size (in) HOLE PREPARATION Torque in ibi F.r (in.) Process Type SPECIMEN 623079 Push, no sleeve Fel Pro 300 0.0235 Mandrel max diameter (in). 0.358 0.045 TEST 358 Mandrei taper fin /in J Sleeve thickness (in) COLDWORK PROCESS Sleeve Orientation Interference (ID.) Mandrel material Lubrication Siere type 300 M stee! (270-300 ksi) Shot peen 0.250 0.75 1.50 35 SPECIMEN DESCRIPTION Material gage (in). Surface treatment Hole spacing (in.) Edge margin (in.) Configuration Width (in) Material

			_	_			, ,		_	_	_						٦	
	Origin of faiture		4 -	C.W.			}	*	- 3	_				\ \ \				
	Cycles 50	Ju'e!		305,000					000'96					-			 	
		F.1		Net	N _o				- Net		Net		-	-	-	-		1
		Diameter.		0.3735	04/5 0	03/40			0.3735		0.3735	-						
Colchage	Papansing (in I	Retained																
3	sueda.	A. tual									_						+	
	=	Ather	ream	۶	3				}	2		-			_	-	1	\downarrow
	Hole finish (RHR)	11.0	coldwork	۱						•		1						
	¥		COLCHAROLE	,		t											_	
			Alter		0.3735	0.3740				0.3735		0.3735						
	Hole diameter (in.)		After coldwork		1	 				1		1						
	HoH		Before		1	1				1		i						
		4.0 H	۶		-	2	3		4	-		2	2	4	-	~	2	4
		Specimen	§ 8		- 11					٥								

agagaras delifikāt militak ka

PHASE II -TASK 3 - BASIC FILLED-HOLE VALUES 300 M, C/W, Filled, 110 KSI, 0.030 Taper, 0.0245 Interference

TEST__359____ SPECIMEN__623079__ DATE__8/16/73__

۶ ور ر		31.4	0.1	4200 cpm	Materials	D. Reese	100.k.o Vibranhore			
FATIGOE CONDITIONS	Max net stress this?	Max test load (kip)	(Sadratio (R)	Vocautient tes I	o o o o o o o o o o o o o o o o o o o		i est engineer	Test machine		
	3/8	C/W, ream, install fastener				LLATION	Hi-Lok, prot no Isteri	0.0005.0.0010 clearance	240	
MOLE PREPARATION	Nominal hole size (in.)	Process C.W				FASTENER INSTALLATION	Type	F.r (in.)	Torque fin th	
	0.0245	Push (no sleeve)			t	Carbide (BAC 5972)	0.030	85.0	Fel Pro 300 in hole	and on mandrel
COLDWORK PROCESS			Steen 14pm	Showe the knees for l	Sie ve orientation	Mandrel Caterial Car	Mandrel taper In 'n l	Mandret roat diameter Int. J. P 258	Fe	
•	. O	1000000	300 M steel (270-300 hs)	1 50	1.50	0.75	0.250	ŀ		
	SPECIMEN DESCRIPTION	Configuration	Atsterial 3	Wedth tea 3	Prog k ty art M	f. to Constant and A		Wateriet gage 1:0	100000000000000000000000000000000000000	

Origin of failure	Carle Dug		E.W.			45° shank fretting-	rusty fretting products	()	- F			-		W.S.	PH				45 shank fretting	
¥.570	fanuer		390,000						349 000	,					264,000			-		
Fastener size lin l	ĭ		0 00010	0.0005				9.90	0 000	0.0005				8	3	0.0005	 - -	 		
Fastener	O i americe		0.3730	0 3735					0.3730	0.3735				100	0.3/35	0.3735				
Coldwork expension (in)	Retained			!!!																
Coldwork expension to	Actual		0 0245	0.0245					0.0245	2000	0.0243			-	0.0245	0.0245				
ā	Alta	1887	02				-		9	1	'		-		2	,	+	_	 -	$\frac{1}{4}$
Hule Linish (RHR)	Atte	Coldwork										_				-				
Ĩ	1000	COMPANY																		
_	- 1	1.6	0 2240	200	0.3740		1		0 27.40	0.3740	0.3740				0.3740		0.3740	_	+	
Hole diameter (in)		Atter coldwork																		
To E		Helore Carthogram		•	-		-													
	1011	2		-	2		٣	4		-	,		3	7		-	2		, -	••
	Spet unen dadi	ç.		61-						-20						-21		<u> </u>		

Control of the Contro

PHASE II -TASK 3- BASIC FILLED-HOLE VALUES
300 M, C/W, Fitled, 110 KSI, 0.045 Taper, 0.020 Interference

16.5T 35.10 SPECIMEN 623079 DATE 8.16/73.

110		10	4200 cpm	Materials	D Reese	100-kip Vibraphore	
FATIGUE CONDITIONS	Man net stems fissi	Max test toad 1kip) Load ratio (R)	Test frequency	Test laborations	[Pri impire:	Test machine	
ATION	13/8	C/W, ream, install fastener			Hi-Lok prothd (steel)	Net	(b)
HOLE PREPARATION	Nominal hale size (in)	Process			FASIENERIN		Torque (in 1b)
	0.0195	Push (no sleeve)			Carbide IBAC 59721	0.3580	Fet Pro 300 on sleeve
COLDWORK PROCESS	Interference (in.)	Sleeve type	Sizewe thickows (m.)	Steme or motation	Mandrel material	Mandrel taper (in 'in) 0.3580	Mandrel max diameter
NOTE OF THE PROPERTY OF THE PR	Fig. 2	Nateral 300 M steel (270-300 ksi)	Width In)	Hale specing	Edge margin (ii) 0.75	Material dage fin 3. 0.250	Surface treatment Shot peen

	Origin of failure		() () () () () () () () () () () () () (PH) 	Large fatigue growth zones						{	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\			soor soor side fretting	1	
	Crota St	Pariure		121,000				000 811						105,000					
1 97, 22		-		1961	ž			Net	2				ž		Nei			_	
	r Witness State	Diameter		0.3740	0.3740			0.3740	0 3340	25/50		1	03740		03740				
Coldwork	u -) u 0	Reta-ned																	
8	u) corsuedxa	Actual		0.0195	0 0 195			0.0195		0.0195				6.0.0	00195				
	æ	After		15	'			15	1	-		-	\\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\	15	1	+			
	Hair finish (RHR)	After	COLORAGO													1			
	Ĭ	Betor	coldwork			1													
		Pira	(Light)	03340		0.3740		30.50	0.3740	0.3740				0.3740		0.3/40			
	Hole (hameter (m.)	After	coldwork											ļ					
	9. 9.	Belore	colthwork																
		olo!			-	2	ю	•	_	2	,	٦	4	-	.	2	5	-	4
		Specimen	?		-22				-23					,	;				

C/W, net fit, Hi-Lok, (0.015 taper mandrel).

300 M

TEST_3511 SPECIMEN 623079 DATE 8/27/73

FATIGUE CONDITIONS Max net stress (ksi) Max test load (kip) Load ratio (R) Test frequency . Test laboratory Ream, C/W, ream 0.375 FASTENER INSTALLATION Nominal hole size (in) HOLE PREPARATION Process Carbide BAC 5972 Push, no sleeve 0.023 Steeve thickness (in.) COLDWORK PROCESS Interference (in.) Sleeve orientation. Mandrel material Sleeve type 300 M steel (270-360 ksi) Fig. 2 1.50 1.50 0.75

SPECIMEN DESCRIPTION

Configuration

100-kip Vibraphore

Test engineer Test machine

Hi-Lok, prct hd

Net to 0.0005 clearance

F.r (in.)

Type

0.015

Mandrel taper (in /in)

240.250

Torque (in. lb)

Fel Pro 300

Lubric st.o'

Mandrel max diameter (iii) 0.358

0.250 Shot peen

Surface treatment.

Material gage (in.).

Hale spacing(in.). Edge margin (in.)

Material Width (in)

Materials
D. Reese

	_				_	_			$\overline{}$				7
Origin of feiture	Origin of failure and remarks				•	PH			-	HH · MO) 	
C _Y ः	failure	287,000				364,000				76,000			
Fastener size (in)	F.1	0.0005	0.0005			Set	Net			Net	Net		
Fastener	Diameter	0.3730	0.3730			0.3735	0.3735			0.3740	0.3740		
Coldwork expension (in)	Retained	1	١			-	-			1	1		
Cold	leu!; A		1			١				1	,		
	After	25	-			25	-			20	1		
Hole finish (RHR)	After	1	1			1	1			1	-		
2	Before	1	1			1	1			1	,		
	After	0.3735	0.3735			0.3735	0.3735			0.3740	0.3740		
Hote diameter (in.)	After					1	1			1	,		
¥	Before					1							
	FO.	-	2	3	4	-	2	3	4	_	~	٣	4
	Specimen dash no		63.			76				.27			

PHASE II TASK 4 - APPLICATION AND PROCESS PARAMETERS

TEST NUMBER:	4 3	.1
NOMINAL EXPANSION	VALU	E:019 "
GENERAL TEST CONDITIONS		DATE: 3-27-73
1 Specimen Description	3.	CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0.250" Surface Treatment: Shor Peen Fastener: None		Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 9 0° CW Mandrel: S1 5300-CBM- 12 -(CW Mandrel Taper: 0.045'/" CW Mandrel Major Dia.: ,3730" Lubrication: Fel Pro 300 (on sleeve)
2. Hole Preparation	4.	Fatigue Conditions
Nominal hale size: 3/8" Process: ream, CW & ream		Net stress: 30 ksi Test load: 8,500 lbs. Load ratio: (R) 0,1
90° Slerve Open Holi		Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 KII

o. R62308()	No.	Hole Diameter (inches)		95) (RHR) > 8 8		1 8	Cycles to Failure (Thousands)	Origin of Failure			
Specimen No.	Hole	Béfore CW	After CW	After ream	Before CW	After CW	After Ream	Actual CV Diametrical Ex (Inches)	Ketained Diametricol Ex (Inches)	Cycles to Fail (Thousands)	and Remarks
	1_	. 3540	. 3665	.3735	60	30	40	.0190	.0125		C.W
-21	2	. 3545	.3665	.3735	60	30	_	.0185	.0120	382	Sleeve Split
-22	1	.3545	.3665	.3735	50	20	45	.0185	.0120	424	C/W
	2	. 3545	.3670	.3735	55			.0185	.0125		Sleeve Split
-23	1	.3540	. 3665	. 3735	60	30	35	.0190	.0125	205	
-23	2	.3540	. 3665	.3735	55	20	-	.0190	.0125	335	Sleeve Split C/W

Taken at Minimum (midpoint)

PHASE II TASK 4 - APPLICATION AND PROCESS PARAMETERS

TEST NUMBER:	4 A 2
NOMINAL EXPANSION	VALUE:0195"
GENERAL TEST CONDITIONS	DATE: 4-17-73
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0.250" Surface Treatment: Shot Pean Fastener: None	Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -0-1 CW Mandrel Taper: 045"/" CW Mandrel Major Dia.: 353" Lubrication: Fel Pro 300 (an sleeve)
2. Hole Preparation	4. Fatigue Conditions
Nominal hale size: 3/8" Process:* Drill CW & ream * Drill with Precision Drill	Net stress: 30 ksl Test lood: 8,590 lbs. Load ratio: (R) 0,1 Test frequency: 5000/minute
Coldworked Good Drilled Hole Open	Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 KIP)

. R623080	No.	Hole Diameter (inches)		inches) (RHR) S (RHR)		ted Exponsion	Failure ands)	Origin of Failure			
Specimen No.	Hole 1	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Ext (Inches)	Cycles to Failure (Thousands)	and Remarks
	1	. 3545	. 3665	.3730	45	20	30	.0185	.0120		
-6	2	. 3545	. 3665	. 3730	-		<u> </u>	.0185	.0120	261	c/w
	1_	.3545	. 3665	.3730	45	20	35	.0185	.0120		
-7	2	. 354 5	. 3665	.3730	_	-	-	.0185	.0120	491	, c\w
	,	.3545	. 366 5	. 3730	50	25	40	.0185	.0120	226	
-8	2	.3545	.3665	.3730	-	-	_	.0185	.0120		C/W

(autycant)

PHASE II TASK 4 - APPLICATION AND PROCESS PARAMETERS

	TEST	NUMBER:	4 A 3		_			
	NOMINAL	EXPANSION V	/ALUE	.: _0.0185"		_		
GEN	ERAL TEST CONDITIONS			DATE: 4	-19-73			
1.	Specimen Description		3.	CW Process				
	Material gauge: 0.25)")" 5" 1 T 851		Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: 353" Lubrication: Fel Pro 300 (on slee				
2.	Hole Preparation		4.	Fatigue Cond	itions			
	Nominal hale size: 3/8" Process: * Drill , CW * Abusively Drille	& ream	-	Net stres Test load Load rati Test Freq	: 8, o:		 - -	
	Coldworked Abusive Open	ly Drilled		Test Labo Test Engi Test Mac	neer:	Materials D. Reese Vibrophore (36 KIP	<u> </u>	
	Hale Diameter	Hole Finish	nsion	\$ \	ę.		_	

o. R623080	Š.	[e Diame inches)	ter		le Fin (RHR)	nish	CW Expension es)	hed Expansion H)	failure ands)	Origin of Failure	
Specimen No.	Hole	Before CW	Afre CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical E	Retained Diometricol Ex (Inches)	Cycles to fail (Thousands)	and Remarks	
	1	.3545	. 3670	. 3730	130	45	30	.0185	.0125			
-9	2	.3545	.3670	.3730	_	_ - _	-	.0185	.0125	110	C/W	
	1	.3545	. 3670	.3730	125	40	35	.0185	.0125			
-10	2	.3545	.3670	.3730	-			.0185	.0125	287	c/w	
	1	.3545	.3670	. 3730	145	35	30	.0185	.0125			
-"	2	.3545	.3670	.3730	-	-	-	.0185	.0125	93	c/w	

Taken at Minimum (midpoint) 3> Hole Bell Mouthed 3> Spiral Gouge in Hole

TEST NUMBER:	4 A 4
NOMINAL EXPANSION	VALUE: 0,019"
GENERAL TEST CONDITIONS	DATE: 3-27-73
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0,250" Surface Treatment: Shot Peen Fastener: None	Sleeve type: Axial Split Sl. zve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -0-N CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: .3730" Lubrication: Fel Pro 300 (on sleeve)
2. Hole Preparation	4. Fatigue Conditions
Nominal hole size: 3/8" Process: ream, CW No Postream Open Hole	Net stress: 30 ksi + Test load: 8,580 lbs, Load ratio: (R) = 0,1 Test Frequency: 5000/m inute Test Laboratory: Materials Test Engineer: D, Reese Test Machine: Vibrophore (36 KIP)

o. R623080	Š.	j	le Diame (inches)	ler		Hole Finish (RHR)		I CW I Expansion ies) .ed Expansion		Failure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks
	1	. 3545	. 3665	•	35	15	-	.0185	.0120		
-24	2	.3545	. 3665	_		_		.0185	.0120	431	
	1	.3545	. 3665	-	30	15	-	.0185	.0120		
-25	2	.3545	3665	-	-	-	-	.0185	.0120	333	
	1	_354v	. 3665	-	35	20	-	0190	.0125		
-26	2	.3540	3665	-] -	_	_	.0190	.0125	330	

^{1 . - 1} of en of Maniagus (unity sint).

GENERAL TEST CONDITIONS		DATE: 3-28-73
1. Specimen Description	3.	CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig 2 Width: 1,50" Hole spacing: 1,50" Edge margin: 0,75" Material: 2024 T 851 Material gauge: 0,250" Surface Treatment: Shot Peen Fastener: None		Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -(CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: ,3530" Lubrication: Fel Pro 300 (on sleeve)
2. Hole Preparation	4.	Fatigue Conditions
Postscore One Hole Open		Net stress: 30 ksi + Test load: 8,500 lbs. Load ratio: (R) = 0,1 Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 KIP)

». R623080	No.		e Diamet	rer		Hole Finish (RHR)		CW Expansion	hed Exponsion es) (↑>	Cycles to Failure (Thousands)	Origin of Failure
Specimen No.	Hole !	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inche	Retained Diametrical Eq (Inches)	Cycles to Fail (Thousands)	and Remarks
27	1	<u>.35</u> 40	.3665	.3730	40	25	45	.0190	.0125	300	C/W
-27	2	.3545	.3665	.3730		-	-	.0185	.0120	300	Fallure in Unscored Hole
20	1	.3545	. 3665	.3730	35	15	50	.0185	.0120	94	
-28	2	. 3545	.3665	.3730	-	-	-	.0185	.0120		Failure in Unscored Hole
	1	.3545	. 3665	.3730	40	20	45	.0185	.0120		
-29	2	.3545	. 3665	.3730	-	_	-	.0185	.0120	393	fallure in C/W Unscored Hole

[] > Taken at Minimum (midpoint)

	I E SI INOMBER:	4 A C	
	NOMINAL EXPANSION	VALU	E. 0.019"
GE	NERAL TEST CONDITIONS		DATE: 3-28-73
1.	Specimen Description	3 .	CW Process
	Zero load transfer, 2 hole, no CSK Configuration: F-9. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material 2024 T 851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: None		Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 -0-N CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: 3530" Lubrication: Fel Pro 300 (on sleeve)
2.	Hole Preparation Nominal hale size: 3/8" Process: Ream, C/W & Ream (full 1/ Full 1/64" Postream Open Hole	4.	Net stress: 30 ks1 † Test load: 8,450 lbs. Load ratio: (R) = 0,1 Test frequency: 5000/minute Test Laboratory: Materials Test Engineer: D, Reese Test Machine: Vibrophore (36 KIP)

o. R623080	No.		e Diamei inches)	ter	Hole Finish (RHR)		CW Expansion net Expansion es)		Failure ands)	Origin of Failure	
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Ex (Inches)	Cycles to Fail (Thousands)	and Remarks
	١	. 3545	. 3665	. 3895	35	15	-	.0185	.0120		
-30	2	. 3545	. 3665	. 3895	-	-	-	.0185	.0120	235	c/w
3,	1	.3545	.3665	. 3895	40	20	35	0185	.0120		
-31	2	,3545	. 3665	.3895	-			.0185	.0120	249	C/W
-32	1	.3545	. 3665	., 3Ł95	45	20	30	.0185	.0120		
-32	2	.3545	. 3665	. 3895	_		_	0185	.0120	214	C/W

Taken at Minimum (midpoint)

	TEST NUMBER:	4	IA7
	NOMINAL EXPANSION	VALU	JE: 0.019"
ĊĘ	NERAL TEST CONDITIONS		DATE: / 3-28-73
1	Specimen Description	3.	CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1 50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T 851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: None		Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve prieritation: 0° CW Mandrel: ST 5300-CBM- 12 -G-N CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: ,3530" Lubrication: Fel Pro 300 (on sleeve)
2	Hale Preparation	4.	Fatigue Conditions
	Process: Ream, C/W, Ream 1/32 as 1/32" Postream Open Hole	_	Net stress: 30 ksi 1 Test load: 8,270 lbs. Load ratio: (R) 0.1 Test Frequency: 5000/mlnute Test Laboratory: Materials Test Engineer: D. Reese
			Test Machine: Vibrophore (36 KIP)

No. R623080	No.		e Diame inches)	ter	Hole Finish (RHR)		CW Expansion es)	ted the Expansion is the second in the second is the second in the secon	Failure ands)	Origin of Failure	
Specimen M	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inche	Retained Diametrical Exp (Inches)	Cycles to Fail (Thousands)	and Remarks
	1	.3545	. 3665	.4075	50	20	55	.0185	.0120		
-33	2	.3545	.3665	.4075	_	-	-	.0185	.0120	283	' c/w
	1	.3545	.3665	.4075	45	20	.45	.0185	.0120		
-34	2	.3545	3665	.4075	-	 	-	.0185	.0120	256	' c,/w
25	1	.3545	. 3665	.4075	35	15	40	.0185	.0120		
-35	2	,3545	.3665	.4075	-	-	-	.0185	.0120	28 5	c/w

Taken of Minimum (midpoint)

	TEST NUMBER:		4 A 8
	nominal expansion v	'ALU	LUE: 0.019"
ĊΕ	NERAL TEST CONDITIONS		DATE: 3-28-73
1	Specimen Description	3.	. CW Process
	Zero load transfer, 2 hole, no CSK Configuration: Fig 2 Width: 1.50" Hole spacing: i 50" Edge margin: 0.75" Material: 2024 J 851 Material gauge: 0.250" Surface Treatment: Shot Pean Fastener: Nane		Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-C8M- 12 -0-N CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: .3730" Lubrication: Fel Pro 300 (on sleeve)
2	Nominal hole size: 3/8" + 1/16" Process: Ream, C/W, Ream 1/16 as 1/16" Postream Open Hole	4	Nor stress: 30 ksi Test Load: 8,000 lbs. Load ratio: (R) C. 1 Test frequency: 5000/minute Lest Laboratory Lest Engineer Lest Machine: Vibrophore (36 KIP)

o. R&23080	, Š	1	le Diame (inches)	ter		Hole Finish (RHR)		CW Expansion es)	kxponsion	Failure ands)	Origin of Failure	
Specimen No.	Hoie	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical E (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks	
	1	. 3545	. 3665	.4375	30	15	2 5	.0185	.0120			
-36	2	.354 5	3665	.4375	-	_		.0185	.0120	312	Reamér C/W Chatter	
-37	1	.3545	. 3665	.4375	35	15	25	.0185	.0120			
	2	3545	. 3665	.4375	-	-	-	.0185	.0120	372	Reamér C/W Chatter	
	1	.3545	.3665	.4375	30	15	30	.0185	.0120			
38	2	.3545	3665	.4375	-	-	-	.0185	.0120	226	Reamer Chatter	

Token at Minimum (midpoint)

				TEST	r NU/	MBER:		ΑŞ				
			N	JANIMO	. EXP	ANSIC	ON V	ALUE: _	0.019"			
Ģ	ENER	AL TEST	CONDI	TIONS				D	ATE:	3-	29-73	
1	. \$p	ecimen [Descriptio	on				3. CW	/ Process			
	Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1,50" Hale spacing: 1.50" Edge margin: 0,75" Material: 2024 T 851 Material gauge: 0,250" Surface Treatment: Shot Peen Faltener: None							Sleeve type: Square Wire Sleeve thickness: 0.018" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: .3530" Lubrication: Fel Pro 300 (an sleeve				
	2. F	tole Prep						4. Fat	igue Cor	nditions		
C/V	√ one	Process: ncounter hale twic	Oper ed with ce - Go	re Sleeve Mole	eve)			Test Lo	ad: 8,2 atio: (fequency: boratory: aineer:	ksi 1 100 lbs. R) = 0.1 5000/minute Materials D. Reese Vibrophore (36 KIP)	
. R623080	, o		e Diamei inches)	ter	Hole Finis			Actual CW metrical Expansion (Inches)	Led Exponsion	, Failure ands)	Origin of Failure	
Specimen No. R623080	Hole No.	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inch	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	and Remarks	
	1	. 3690	.3800	. 3895	35	_	40	.0200	.0110			
12	2	.3690	. 3800	. 3895	-	-	-	.0200	.0110	167	c∧	
	1	, 3690	.3800	. 3895	30	-	30	.0200	.0110			
13	2	.3690	. 3800	.3895	-	-	-	.0200	.0110	339	\ c^	
	1				 -		1					

.0200 .0115

586

 $V \to A_{\rm e} V \cos \alpha t Maximum (may red)$

TEST NUMBER	481
NOMINAL EXPANSION	VALUE: 0.019"
GENERAL TEST CONDITIONS	DATE: 3-27-73
1. Specimen Description	₹ N. W. Process
Zero load transfer, 2 hole, no CSK Configuration: Fig 2 Width: 1,50" Hole spacing: 1,50" Edge margin: 0,75" Material: 2024 T851 Material gauge: 0,060" Surface Treatment: Shot Peen Fastener: None	Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: SI 5300-CBM- 12 -0-N CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia.: .3730" Lubrication: Fel Pro 300 (on sleeve)
2. Hole Preparation Nominal hole size: 3/8" Process: Drill, ream, CW & ream .060 Gage Open Hole	A. Fatigue Conditions Net stress: 30 ksl Test load: 2,150 lbs. Load ratio: (R) = 0,1 Test Frequency: 3500/minute Test Laboratory: Materials Test Engineer: D Reese Test Machine: Vibrophare (36 K lp)

. R623080	No.		e Diame inches)	ter		le Fin (RHR)	ish	CW Expansion es)	bed Expansion	Failure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Ex (Inches)	Retained Diametrical Expansion (Inches)	Cycles to Failure (Thousands)	and Remarks
-1	1	.3540	.3665	.3735	40	20	30	.0190	.0125	48	TIE CW
	2	.3540	.366 5	.3735	-	•	-	.0190	.0125		
-2	1	.3540	.3665	.3735	40	20	2 5	.0190	.0125	49	CW
	2	.3540	.3665	.3735		-		.0190	.0125		<u> </u>
-3	١	.3540	.3665	.3735	40	. ၁	30	.0190	.0125	4.5	
Ľ	2	.3540	.3665	.3735		-	-	.0190	.0125	65	CW

Toker at Minimum (midpoint)

PHASE IT TASK 4 - APPLICATION AND PLOTE PROPERTY

	TEST NUMBER:	4 C 1
	NOMINAL EXPANSION Y	ALUE 0.019 (One Hole)
GE	NERAL TEST CONDITIONS	DATE: 3-30-73
ī	Specimen Description	3 CW Process
	Zera load transfer, 2 hole, no CSK Configuration: Fig 2 Width: 1,50" Hole spacing: 1,50" Edge margin: 0.75" Material: 2024 T851 Material gauge: 0,250" Surface Treatment: Shot Peen Fastener: Prot Hd. Hi~Lo ¹	Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 00 CW Mandrel: ST 5300-CBM: 12 -0:1 CW Mandrel Toper: 0.045"/" CW Mandrel Major Dia: .3530 Lubrication: Fel Pro 300 (an sheeve)
2	. Hole Preparation	4. Fatigue Conditions
	Nominal hole size: 3/8" Process: 1_Ream C/W, Ream & Install F 2. Ream and Install Fastener Fastener Inst1. Torque: 225-250 in/1bs Fastener Dlameter: .3735 One Hole Not C/W Filled Holes	Net stress: 30 ksi Test load: 8.550/lbs Load ratio: (R) (i.1) Test frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophare (36 Kip)

. R623080	Zo.	1	e Diamet	er		le fin (RHR)	ish	I CW I Expansion ses)	Expansion es)	Cycles to Failure (Thousands)	Origin of Failure and Remarks
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual Diametrical (Inche	Retained Diametrical Expansion (Inches)	Cycles to Fail (Thousands)	
-57	1 2	.3545	.3665	.3735	40	20	25	.0185	.0125	855	failure at non-
-58	1 2	.3540	.3660	.3735	30	15	30	.0190	.0120	703	failure through coldworked hole
-59	1 2	.3540	.3565	.3735	35	15	30	.0190	.0125 -	3 75	failure at non- coldworked hole

Token at Minimum (midpoint)

TEST NUMBER:	4 C 2
NOMINAL EXPANSION	N VALUE: 0,019"
GENERAL TEST CONDITIONS	DATE: 3-30-73
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 1851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: Prot.Hd. Hi-Lok (.002 Clearance FIt)	Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 - CW Mandrel Taper: 0.045"/" CW Mandre Major Dia.: .3530 Lubrication: Fel Pro 300 (on sTeeve
2 Hale Preparation	4 Fatigue Conditions
Nominal hale size: 3/8" Fromess Ream, CW & ream Fastener Torque: 225/250 in/Tbs Fastener Diameter: ,3735 .002" CL, Hi-Lok Hole C/W	Net stress: 30 ksi Test load: 8.550 lbs. Load ratio: (R) = 0.1 Test Frequency 5000/minute Test Laboratory Materials Test Engineer: D, Reese Test Machine: Vibrophore (36 Kip)

. R623080	° Z)	e Diame inches	Feri		le Fin (RHR)	ish	CW Exponsion es)	bed Expansion (1)	Failure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	Afler reom	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Exp (Inches)	Cycles to Foilure (Thousands)	and Remarks
1	1	.3540	.3665	.3755	35	15	30	.0190	.0125	404	head
-42	2	.3540	.3665	.3 755	-	-	-	.0190	.0125	694	
-43	1	.3540	.3665	.3755	30	15	25	.0190	.0125	366	heod
	2	.3540	.3665	.3755	-	-	_	.0190	.0125		'
	1	.3540	.3665	.3755	30	15	30	.0190	.0125	697	head
-44	2	.3540	.3665	.3755	_	_	-	.0190	.0125		ess

Taken at Minimum (midpoint)

1E21 MOWREK:	4 4 3
NOMINAL EXPANSION	VALUE: 0.019"
GENERAL TEST CONDITIONS	DATE: 4-16-73
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 1851 Material gauge: 0.250" Surface Treatment: Shat Peen Fastener: HI-Lok (.002" interference)	Sleeve type: Axial Split Sleeve thickness: 0.010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- T2 CW Mandrel Taper: 0.045"/" CW Mandrel Major Dia: .353" Lubrication: Fel Pro 300 (on sleeve
2 Hole Preparation	4. Fatigue Conditions
Process: Ream, CW & ream Fastener Diameter: .3535 Fastener Inst'l Torque: 225/250 In/Ib. C/W .002 Interference HI-Lok	Net stress: 30 ksi Test load: 8,630 lbs. Load ratio: (R) 0.1 Test Frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 Kip)

. к623080	Š	1	e Diame inches)	ter		le Fin (RHR)	ish	CW Expansion es)	txpansion	Failure ands)	Origin of Failure
Specimen No.	Hole (Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Ex (Inches)	Cycles to Failure (Thousands)	and Remarks
	١	.3540	.3665	.3710	35	15	30	.0190	.0125	120	neco
-45	2	.3540	.3665	.3710	-	-	-	.0190	.0125		,
	1	.3540	, 366 5	.3710	40	20	25	.0190	.0125	185	head
-46	2	.3540	.3665	.3710	-	-	-	.0190	.0125		
	1	.3540	.3665	.3710	30	15	30	.0190	.0125	258	head
-47	2	.3540	.3665	3710	-		-	.0190	.0125	1	

Taken at Minimum (midpoint)

NOMINAL EXPANDION VALUE: 0.019"

GENERAL TEST COL	NDIT	1004
------------------	------	------

DATE: 4-2-73

1.	Specimen	Descrip	tion
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Zero load transfer, 2 hole. CSK

Configuration: Fig 2

Width: 1.50"

Hole spacing: 0.75"

Edge margin: 0.75"

Material: 2024 T851

Material gauge: 0.250"

Surface Treatment: Shot Peen

Fastener: Hi-Lak 100 Hd., Net Fit

CO Process

Sleeve thickness: 0,010"

Sleeve thickness: 0,010"

Sleeve orientation: 0°

CW Mandrel: ST 5300-CBM- 12 -0-N

CW Mandrel Taper: 0,045"/"

CW Mandrel Major Dia: ,353

Lubrication: Fel Pro 300 (on sleeve)

2. Hole Preparation

Nominal hale size: 3/8"

Process: Ream, C/W, Ream & CSK

Fastener Diameter: .3538-.3540

Fastener Inst'l Tarque: 225/250 in/lbs

100° CSK after C/W Net Fit HI-Lok

4. Fatigue Conditions

Net stress: 30 ksi

Test load: 8.600 lbs.
Load ratio: (R) = 0.1

Test Frequency: 5.000

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Vibrophore (36 Klp)

R623080		ю.	Hole D (inch		ır	Hole Finish (RHR)			ol CW ol Expansion hes)	Exponsion les)	to Failure usands)	Origin of Failure
Specimen No.		Hole N	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Diametrical (Inche	Retained Diametrical Ex (Inches)	Cycles to Failu (Thousands)	Remarks
		1	.3540	.3665	.3735	35	15	30	T		1,247	
-	48	2	.3540	.3665	.3735	-	-		.0190	.0125		EXT7
		1	.3540	.3665	.3735	40	20	45	.0190	.0125	950	
-	49	2	.3540	.3065	.373.	3 -		_	.0190	.0125	 	
		1	.3540		_3 54	40	20	3.5	.0190	.0125	1,186	1-7-H
-	-5 0	2	1		.354	d -	<u> </u>	_	.019	0 .0125		

> Taken at Minimum (midpoint)

GENERAL TEST CONDITIONS		DATE: 4-2-73
1. Specimen Description Zero load transfer, 2 hole Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T851 Material gauge: 0.250 Surface Treatment: Shot Fastener: H1-Lok 100" H	reen	Sleeve type: Axial Split Sleeve thickness: 0,010" Sleeve orientation: 0° CW Mandrel: ST 5300-CBM- 12 - CW Mandrel Taper: 0.045"/" CW Mandrel Major Dio.: .353" Lubrication: Fel Pro 300 (on sleeve
Nominal hale size: 3 Process: Ream, CSK, C/ Fastener Diameter: ,374 Fastener Inst'l Tarque: 100° CSK Before C/ Net Fit Hi-Lok	10 225/250 in/lbs	Net stress: 301 ks1 Test load: 8,550 lbs. Load ratio: (R) = 0.1 Test frequency: 5000/minute Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Vibrophore (36 Kip)
Hole Diameter	Hole Finish	ation Use

o. R623080	Že.	_	e Diame inches)	ter		le Fin (RHR)	ish	CW Expansion es)	bed Exponsion 53)	Failure anais)	Origin of Failure and Remarks
Specimen No.	Hole	Before CW	After CW	After reom	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Exp (Inches)	Cycles to Failure (Thousands)	
	1	.3540	.3665	.3740	25	15	40	.0190	.0125	140	
-51	2	.3540	.3665	.3740	-	-	•	.0190	.0125	169	
	1	.3540	.3665	.3740	30	15	40	.0190	.0125	508	
- 52	2	.3540	.3665	.3740	-	-	-	.0190	.0125		,
	1	.3540	.3665	.3740	30	15	45	.0190	.0125	213	
-53	2	.3540	.3665	.3740	-	-	-	.9190	.012	<u> </u>	

Taken at Minimum (midpoint)

		TES	T NUMBER:	40	2 6			
		NOMINA	L EXPANSION	VALU	E: .0185			
g	ENE	RAL TEST CONDITIONS			DATE:	4-16-	-73	
1	. Sp	pecimen Description Zero load transfer, 2 ho	ile	3.		ve type:	Axial Split	
		Configuration: Fig. 2 Width: 1.50 Hole spacing: 1.50 Edge margin: 0.7)''		Sleev CW 1	ve orient Mandrel:	ST 5300-CBM-	12 -0-1
		Edge margin: 0.7: Material: 2024 YB Material gauge: 0.25 Surface Treatment: Sho Fastener: HI-Lok with	0" Or Peen		CW	Mandrel Mandrel cation:	Toper: 0.045"/ Major Dia.: 35 Fel Pro 300 (or	530
	2. 1	Hole Preparation		4.	Fatigue C	ondition	15	
		Nominal hole size: Process: Drill, ream, C Fastener Diameter: 38 Fastener Inst'l Torque: Fastener Flt: Net 70° CSK after C Net Fit Hi-Lok	225/250 "/in.lb	_	Test: Load Test Test	stress: lood: ratio: Frequence Loborato Engineer Machine	Materials D. Reese	
200		Hole Diameter	Hole Finish		, is	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \		

, 3623080	No.	Fole No. Tream Tream Tream Actual CW Retained Metrical Expansion (Inches) Retained Metrical Expansion (Inches) Tream Actual CW Actual CW Metrical Expansion (Inches) Tream Actual CW Tream Actual CW Actual CW Tream		(inches)					s Failure ands)	Origin of Failure	
Specimen No.	Hole	Before CW	Afrer CW	After reom	Before CW	After CW	After Ream	Actual Diametrical	Retained Diametrical Expansion (Inches)	Cycles to Fail (Thousands)	and Remarks
-54	1	.3545	.3665	.3800	40	20	3 5	.0185	.0120	200	
	2	.3545	.3665	.3800	-	_	-	.0185	.0120	290	
55	1	.3545	.3665	.3800	3 5	15	40	.0185	.0120	315	
-55	2	,3545	.3665	.3800	- _	-		.0185	.0120		
	1	.3545	.3665	.3800	40	20	35	.0185	.0120	191	
-56	2	.3545	.3665	.3800		-	-	.0 185	.0120	,,,	

Taken at Minimum (midpoint)

TEST NUMBER:	4 C 7
NOMINAL EXPANSION	VALUE: 0.019
GENERAL TEST CONDITIONS	DATE: 4-25-73
1. Specimen Description	3. CW Process
Zero load transfer, 2 hole, no CSK Configuration: Fig. 2 Width: 1.50" Hole spacing: 1.50" Edge margin: 0.75" Material: 2024 T851 Material gauge: 0.250" Surface Treatment: Shot Peen Fastener: Prot. Hd. Net Fit HI-Lok	Sleeve type: Axial Split Sleeve thickness: 0,010* Sleeve orientation: 0^ CW Mandrel ST 5300-CBM- 12 CW Mandrel Taper: 0.045**/* CW Mandrel Major Dia.: ,3530 Lubrication: Fel Pro 300 (on sleeve
2. Hole Preparation Nominal hale size: 3/8" Process: 1. Ream. 2. Install under-size fastener Reamed only with Hi-Lok Test at 30 ksi	4. Fatigue Conditions Net stress: 30 ksi Test load: 8,750 lbs. Load ratio: (R) = 0,1 Test frequency: 5000/minute Test Laboratory: Materials Test Engineer: D, Reese Test Machine: Vibrophore (36 Kip)

o. R623080	No.		le Diame (inches)	ter		le Fin (RHR)	ish	CW Expansion es)	Fed Expansion (%)	Foilure ands)	Origin of Failure
Specimen No.	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual C Diametrical Es (Inches)	Retained Diametrical Exp (Inches)	Cycles to Foilure (Thousands)	and Remarks
-15	1	-	-	.3430	-	-	-	_	-	172	
-13	2	-	-	.3430	_	-	•	~	-	1/2	
	1	•	_	.3430	<u>-</u>	-	_	_	-	200	
-16	2	ı	-	.3430	-		-		-	200	
	1		-	.3430	•	_	_	_	-	222	
-17	2	•	-	.3430	-	-	_	-	-		

1 Taken at Minthium (midpoint) Test engineer did not stop at 80,000 cycles

				TE	ST NU	IMBER	:	4 C 8			
			2	OMINA	L E XF	PANSI	ON \	/ALUE:	0.019"		Precracked and C/W net-fit Hi-Lok 30 ksi
	SENE	RAL TES	COND	MIONS				!	DATE:	4-3-73	
1		Zero la Configu Width: Hale sp Edge m Materia Surface Fastene	orgin:	fer, 2 he Fig. 1 2024 : 0	2 50" 75" 7851 .250"				Sleevi Slervi CW M CW M	type A thickness correntation andrel S andrel Tap andrel Ma ation: F	on: 0° 1 5300-CBM ~ 12 -0-
			3. Red 4. C/ 5. Red	ot Drill tch (fatl ve .030" am dia. am	' cracl (at 30	cleng ksi)	to len	pre C∕W • 030	Test Lo Test Er Test M	ad: atio: (requency: aboratory: agineer: aachine:	30 ksl 8,650 lbs. R) 0 l 5000/minute Materials D. Reese Vibrophore (36 Kip)
Specimen No. R623080	Hole No.	Hole Diameter (inches)			J	le Fin (RHR)	ish	Actual CW Diametrical Expansion (Inches)	ned Expansion es)	Cycles to Failure (Thousands)	Origin of Failure
Specimen N	Hole	Before CW	After CW	After ream	Before CW	After CW	After Ream	Actual Digmetrica	Retained Diametrical Expansion (Inches)	Cycles 1 (Thou	and Remarks –failure origin
	1	.3540	.3670	.3735	40	20	45	.0190	.0130	30 to crac 93 after C	w 1
-18	2	.3540	.3670	.3735	-	-	-	.0190	.0130	123 total	Orig. crack after C/W
	1	.3540	.3670	.3735	40	20	50	.0190	.0130	32 to crac 515 aft CV	
-19	2	.3540	.3670	.3735	-	-	_	.0190	.0130	547 total	Orla crack at hole of arr. Was postreom
		 			 		 	 	 	10:45	5=1025 000

334

.3540 .3670

.3670

Taken at Minimum (midpoint)
Pilot Hole Dia. = .3155"

.3735 35

.3735

15

.0190

.0190

.0130

.0130

3>-18 (30,000 cycles - .050 crack) -19 & -20 .050" crack (gives .030" at .354" diameter)

607 aft. W 2

625 tota Orlg.crack .021 afte

TEST NUMBER	4 D 1	(Edge Margin) (Open Holes
NOMINAL EXPANSION		

DATE:__

GENERAL TEST CONDITIONS

Specimen Description

Tributa.

Edge Margin - 4 l	Hole, No CSK	
Configuration:	Fig. 7a	
Width:	3.124	
Hole spacing:	1.50" x 2.00"	
Edge Margin:	.562	_
Material:		
Material Gage:	0.025 Inch	
Surface Treatment	t: Shot Peen	_

2. Hole Preparation

Nominal	Hole Size:_	3/8 Inch
		dwork , Ream

1-1/2D E/M C/W open hole 30 ksi

Fastener: None

3. CW Process

Sleave	Type: Split
Sleeve	orientation:

4. Fatigue Conditions

Net Stress: 30 ksi	
Test Load: 18,115 lbs	_
Load Ratio: R= 0,1	_
Tes: Frequency: 5000/Min.	_
Test Laboratory: Materials	_
Test Engineer: D. Reese	_
Test Machine: Vibraphare (36 K	Ī

s. R623080	No.	ŀ	dole Diameter (Inches)		Hole Finish (RHR) Final Ream	failure nds)	Origin of Failure and Remarks	
Specimen No.	Hole 7	Before CW	After CW	After Ream		Cycles to Fai (Thousands)		
	1	.3540	. 3665	.3735	35			
-89	2	.3542	. 3665	.3735	-	359		
] -0/	3	.3542	. 3665	. 3735	35	337	cw	
	4	.3544	. 3665	.3735	-	1	Cit	
	1	. 3545	. 3665	.3735	40		(alarata)	
	2	.3545	. 3666	.3735	-	1		
-90	3	.3545	.3666	, 3735	45	215	''	
1	4	.3545	. 3668	. 3735	-	1	CW	
		.3545	.3666	. 3735	40		Cathodia	
1	2	.3544	. 3666	. 3735]		
-91	3	.3544	. 3664	. 3735	35	183	! ' ' ↑	
]	4	.3545	. 3667	. 3735	-	1	CW	

TECT NUMBER 4 D 2 (Edge Morgin) (Open Holes)

GEN	VERAL TEST CONDITIONS	DATE	F
١.	Specimen Description	3.	CW Process
	Edge Margin - 4 Hole, No CSK Configuration: Fig 7b Width: 3.50" Hole spacing: 1.50 " x 2.00" Edge Margin: .750" Material: 2024-I851 Material Gage: 0.025 Inch Surface Treatment: Shot Peen Fastener: None		Sleeve Type: Split Sleeve arientation: 0
2.	Hole Preparation	4.	Fatigue Canditions
	Nominal Hole Size: 3/8 Inch Process: Ream, Coldwork, Ream	-	Net Stress: 30 ksi Test Load: 20,860 lbs Load Ratio: R= 0.1 Test Frequency: 5000/Min. Test Laboratory: Materials Test Engineer: D. Reese
	2D E M C/W open hole		Test Machine: Vibrophore (36 KII

. R623080	1 2 3 4 1 2 3 4 1 1 2 3 4 1 1 2 2 1 2	Н	lole Diameter (Inches)		Hale Finish (RHR) Final Ream	Failure nds)	Origin of Failure and Remarks			
Specimen No.		Before CW	After CW	After Ream		Cycles to Fail (Thousands)				
	1	.3540	. 3667	. 3735	35					
-93	2	.3542	. 3666	. 3735	-	504				
	3	.3544	.3666	. 3735	-	1				
ł	4	.3543	. 3665	.3735	35]				
		.3544	. 3667	. 3735	35					
-94	2	. 3535	. 3667	. 3735	-	535				
	3	.3542	. 3668	. 3735	40	1	1 ' '			
	4	. 3542	. 3667	.3735	35	1				
		. 3543	. 3667	.3735	40		Catacata			
-9 5	2	.3542	. 3668	.3735	35	253				
	3	.3544	. 3667	. 3735	40	1 - 1	' '			
	4	. 3543	.3667	. 3735	35	1]			

TEST NUMBER	4 D 3 (Edge Margin) (Open Holes)
NOMINAL EXPANSION VALUE:	0.019 Inch

DATE:

GENERAL TEST CONDITIONS

Specimen Description

萨尔克·

Edge Margin - 4 Hole, No CSK
Configuration:

Width:

3.874
Hole spacing:

Edge Margin:

2024-T851
Material Gage:

Surface Treatment:

None

3. CW Process

Sleeve Type: Split
Sleeve orientation: 0°

2. Hole Preparation

Nominal Hale Size: 3/8 Inch
Process: Ream, Coldwork, Ream

4. Fatigue Conditions

Net Stress: 30 ksi
Test Load: 23,725 lbs

Load Ratio: R= 0,1
Test Frequency: 5000/thin,
Test Laboratory: Materials
Test Engineer: D, Reese
Test Machine: Vibrophore (36 KIP)

2-1/2D E/M C/W open hole 30 ksi

No. R623080	٠٥2	Н	lole Diameter (Liches)		Hole Finish (RHR) Final Ream	cles to Failure (Thousands)	Origin of Failure and Remarks					
Specimen	Hole	Before CW	After CW	After Ream		Cycles to (Thousa						
	1	.3542	. 3670	. 3735	40							
-	2	. 3542	. 3673	. 3735	-]						
-97	3	.3542	. 3670	. 3735		756						
L	4	. 3542	. 3670	. 3730	35]						
	1	.3543	. 3669	. 3735	35		(-als-als-)					
-98	2	. 354 5	. 3669	. 3735	-	202						
-70	3	.3542	. 3669	. 3735		393	, ,					
L	4	. 3543	. 3673	. 3735	35]						
	1	. 3544	. 3673	. 3735	40		Cate sta					
	2	.3543	. 3670	. 3740	35]	الطباطباك					
-99	3	.3544	.3672	. 3735	35	254	, '					
1	4	.3544	. 3672	. 3735	35		1					

TEST NUMBER	4 D 4 (Edge Margin) (Open Holes
NOMINAL EXPANSION \	VALUE: 0.019 Inch

DATE:

1. Specimen Description

Edge Margin - 4 Hole, No CSK

Configuration: Frg 7d

Width: 2.994

Hole spacing: 1.50" x 1.12"

Edge Margin: .9.37

Material: 2024-1851

Material Gage: 0.025 Inch

Surface Treatment: Shat Pean
Fastener: None

3. CW Process

Sleeve Type: Split O

2. Hole Preparation

Nominal Hole Size: 3/8 Inch
Process: Ream, Coldwark, Ream

4. Fatigue Conditions

Net Stress: 30 ksi

Test Load: 17,330 lbs

Load Ratio: R= 0,1

Test Frequency: 5000/Min,

Test Laboratory: Materials

Test Engineer: D, Reese

Test Machine: Vibrophore (36 KIP)

3D hole spacing C/W open hole 30 ksi

No. R623080	No.	Н	lole Dlameter (inches)		Hole Finish (RHR) Final Ream	Failure inds)	Origin of Failure and Remarks			
Specimen N	Hole N	Before CW	After CW	After Ream		Cycles to Fail (Thousands)				
	1	.3545	. 3665	. 3535	35					
-101	2	. 3544	. 3665	. 3535	-	339				
1-101	3	.3544	. 3665	.3535	<u> </u>] 337	CW			
	4	.3544	. 3665	. 3535	35	l	CW			
		.3543	. 3665	. 3535	35]	و دستهاستان			
-102	2	.3540	. 3665	.3535	40	355	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \			
1	3	. 3542	. 3665	. 3535	40]	Crack occurred between holes			
L	4	.3542	. 3665	. 3535	35	1	between holes			
	1	.3540	3666	. 3535	40]	(
1	2	.3542	. 3665	. 3535	-	١				
-103	3	. 3542	. 3665	. 3535		380	cw			
Ì	4	. 3539	. 3665	. 3535	40	L				

TEST NUMBER 4 D 5 (Edge Margin) (Open Holes)
NOMINAL EXPANSION VALUE: 0.019 Inch

GENERAL	TEST	CON	DI	tions
---------	------	-----	----	-------

DATE:

1. Specimen Description

Edge Margin - 4 Hole, No CSK

Configuration: Fig. 7c

Width: 3.374

Hole spacing: 1.50" × 1.50"

Edge Margin: .937

Material: 2024-1851

Material Gage: 0.025 Inch

Surface Treatment: Shot Peen

Fastener: None

3. CW Process

Sleeve Type: Split Sleeve orientation: 0

2. Hole Preparation

Nominal Hole Size: 3/8 Inch Process: Ream, Coldwork, Ream

4. Fatigue Conditions

Net Stress: 30 ksi
Test Load: 19,900 lbs
Load Ratio: R= 0,1
Test Frequency: 5000/Min.
Test Laboratory: Materials
Test Engineer: D, Reese
Test Machine: Vibrophore (36 KIP)

4D hole spacing C.W open hole 30 ksi

No. R623080	Š	Н	iole Diameter (inches)		Hole Finish (RHR) Final Ream	Failure ands)	Origin of Failure and Remarks
Specimen N	Hole N	Before CW	After CW	After Ream		Cycles to Fail (Thousands)	
	1	. 3543	. 3665	. 3735	40		TEST
105	2	. 3543	. 3666	. 3735	-	300	
-105	3	.3542	. 3666	. 3735	40]	CW
]	4	.3542	. 3666	. 3735	·	<u> </u>	
	1	.3544	. 3670	. 3735	40		، صابحات
1,00	2	.3543	. 3670	. 3735	-	294	(MIRAPA
-106	3	.3543	. 3670	. 3735	35] "'	CW
	4	. 3543	.3670	.3/35	40]	
	1	.3543	.3670	. 3735	35		(atenta)
]	2	.3542	. 3670	. 3735	40]	
-10	3	.3543	.3670	. 3735	40	272	cw
	4	.3543	. 3670	. 3735	35]	

		A voet il rosing	APPLICATION	SUPPLIES TABLE APPLICATION AND PROCESS PARAMETERS	
		71707 - 1707 -	2024, 15-Hole, S	2024, 15-Hole, Single, C/W, Filled	2024 15 hole single coupon
		TEST	TEST E1 SPECIMEN	SPECIMEN 623080 DATE 5/9/73	
SPECIMEN DESCRIPTION	NOIL	COLDWGRK PROCESS		HOLE PREPARATION	FATIGUE CONDITIONS
Configuration	F .9 9	Interference (in.)	0.014/0.015	Monunal Pole w/e (m.)	Max cost stress (84c) 40
Maranal	2024 1851	Sleeve 1ype	Split	Prox res	Star test food full.
3	1.00	Slerver thickness (in)	800.0		Load ratio (R) 0.1
Holy specing	1.00	Shive other lation	00		Test frequency 60
(of poster exp	0.50	Mandrel material	H.11 stee	FASTENER INSTALLATION	Ten laboratery Ma
Material (BOP (m.)	0.250	Mandrel taper In /in I	5,0.0	Type Hitlok, 1/4-m prothd	Test enqueer
Sorlage treatment	Shot peen	Mandrel max diameter (in)_0.2300	0.2300	Fit	Tr.t nuchor
		Lubroator	Fel Pro	Torque (in 1h) 80 (stringer only)	

Origin of failure and remarks		}				_							
Cycles 10 farure		149,850				150,320				135,990			
res (12.4)	<u>.</u>												
Fasterne see the	Diameter												
7.0r) K n (m)	H. Tarmerd												
(Fordy, Or (n.)	ارد. ا د	0.015				0.015				0.015			
	Atter	20				25				8			
Hole traish (RHH)	Atim												
Ī	Butore cardwork												
	Aller	0.2485				0.2485				0.2485			
Hole dameter (m.)	Atter												
Hote da	Betorn	0.2310				0.2310				0.2310			
	, (s)	-	2	3	4	-	2	3	7	-	2	3	4
	dest on	83				-84				-85			

a Typical hole measurement

PHASE II -TASK 4 - APPLICATION AND PROCESS PARAMETERS

2024, 15-Hole, Dual, C/W, Filled, One At Time

2024
15 hole dual coupon
C/W and filled one
at time (net-fit)

TEST F1 SPECIMEN 623080 DATE 5/9/73

1	:0	, ,	3	22.7	0.1	fill com		Materials	D. Reese	Richle-Los	
	FATIGUE CONDITIONS		Max net stress (ksi)	Max test load (kp) 22.7	Load ratio (R)	1	Anisanhair sear	Test lationatory	Test engineer	Test machine	a time)
	HOLE PREPARATION	W	Actinization to the state of th	Process Ream, C/W, ream				FASTENER INST/ LLATION	Type. Hi-Lok, 1/4-in. prot hd	Fir.	Torque (in. lb) 80 (fasteners installed one at a time)
	DWORK PROCESS	Interference (in.) 0.014/0.015	!	Steeve type	Sleeve thickness (in.) 0.008	Steeve orientation.	H	arkirel material	Mandrel taper (in./in.) 0.015	Nandrel max diameter (in.) 0.2300	Lubrication Fel P:0
	SPECIVEN DESCRIPTION COL	Contiguestion Fig 8	3024.T851	100 130 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Width tin) Skin-2.50; stringer-1.00	Hole spacing 1.00	Erre marge 1.0.) Skin-1.25; stringer-0.50		Mate at gage tin) U.Z50	Surface treatment. Shot peen	

	Origin of failure and remarks					Fretting evident on surfaces C/W Hole 8) 	Ting on surface	nd notes		
<u> </u>	to	265,000	200,000				764,000			700 000 CAM	7		
Size (in.)	F.t												
Fastener size (in.)	Diameter												
Coidwork expansion (in.)	Retained												
Con	Actual	0.015				0.016				0.015			
æ	After	15				2				15			
Hole finish (RHR)	After coldwork												
Ψ	Before coldwork												
2	After	0.2485				0.2485				0.2485			
in).e diameter (in.)	After coldwork												
.£	Settore control	0.2310				0.2310				0.2310			
ž	و <u>ة</u> و		2	۲)	-7		2	m	4	-	~	c,	.,
Specimen	٤	-86				-87				-88			

a Typical hole measurement

APPLICATION AND PROCESS PARAMETERS	2024, 15-Hole, Dual, C/W, Filled, Production Technique
PHASE II -TASK4	

5/9/73
<u> </u>
ă
SPECIMEN 623080
TEST F2

:	91.30	Gross-26.1 Net-22.6	1	600 cpm	Materials	D. Reese	Rienle Los	est)
FATIGUE CONDITIONS	Max net stress (ksi)	Gross—26. Max test load (kipl Net-22.6.	Load ratio (R)	Test frequency 6	Test laboratory N	Test engineer	Test machine	instailed first, then the r
HOLE PREPARATION	Nominal hole size (in.).	Process			FASTENER INSTALLATION	Type. Hi-Lok 1/4-in. prot hd	F.1. (in.) 0.0015	Torque Inn. 16) 80 (middle, two end fasteners instailed first, then the rest)
	0.014/0.015	Split	0.008	0.	H-11 steel	0.015	0.2300	Fel Pro
COLDWORK PROCESS	Interference (in.)	Steeve type	Seeve thickness (in.)	Sleeve orientation,	Nandrel material	Mandrel taper (in /in.)	Mandret max diameter (in.).	Lubrication
	F. 98	2024-1851	Width (in) Skin-2.50; stringer-1.00	1.00	Ecty margn lun) Skin-1,25; stringer-0.50 Nandrel material	0.250	Shot peen	,
SPECIVEN DESCRIPTION	Conhauration	2000	Width In 1 Skin-	riole spacing	Edge margin lin)	Moneral gage lan! 0.250	Surface treatment	

										_				1
Orion of fasture	and tensaris	C/W Stringer - hole 3	PH PH PH PH PH PH PH PH		Fretting on surfaces Skin-Hole 2	C/W Hd Hole 5			Fretting on surfaces	C/W Hd Hole 4			Fretting on surfaces	
Cycles	to failure	153,000				146,000				273,900				
Fastener size (in.)	Fit	(q)				(g)				9				
Fastener	Diameree													
Coldwork expansion (in.)	Retained													
Соі	Actual	0.015				0.015				0.015				
R)	After	15				52				52				řes Š
Lote finish (RHR)	After coldwork													c Net stress
954	Before coldwork													tress
ť.	After	0.2485				0.2485				0.2485				b Gross stress
Hole diameter (in.)	After coldwork													nent
HOI	Before coldenoris	0.2310				0.2310				0.2310				a Typical hole measurement
ò	<u>ه</u> و	-	2	3	4	1	2	3	7	-	2	3	7	ypical h
Specimen	ā 8	-88				06-				-91				e

Best Available Copy

PHASE II - TASK 4 - APPLICATION AND PROCESS PARAMETERS 2024, 15-Hole, Dual, C/W, Filled, No Postream 15 hole dual coupon C/W- hilled, no postream no postream	COL DWORK PROCESS	Fig. 8 Interference (in.) 0.014/0.015 Norminal hole size (in.) 1/4 Max net stress (6si) 40	2024-T851 Steeve type Split Process Process Ream, C/W Max rest load (kip) 26.5	2): Stringer - 1.00 Steeve thickness (in) 0.008	1.00 Sleeve orientation. 0 Test frequency 600 cpm	-1.25, stringer -0.50 Mandrel marerial		Shot peen Mandrel max diameter (in.) 0.2380 Fit Net Test machine Riehle-Los	Fel Pro
	SPECINEN DESCRIPTION	Cart guston Fig.8	Vater 3	Width In , Skin-2.50, stringer-1.00	HOVE SOMEONING	Euge marga (in) Skin-1.25; stringer-0.5	Material gage fin) 0.250	Surface treatment Shot peen	

Origin of failure	and remarks	Stringer-hole 3		→	es Skin-hole 2	Stringer – hole 9		7	les Skin-hole 10	Hole 11		→ (- -	Jes
Origin	pue	c/w		 - -	Fretting both sides	- - - - - -		<u> </u> 	Fretting both sides	 		<u> </u> - -	Fretting both sides
Cyc. c	10 failure	154,600				157,200				165,500 : C/W			
Fastener size (in.)	Ĩ												
Fastener	Diameter												
Coldwork expansion (in.)	Retained												
Colc expans	Actual												
J.	After	20				25				20			
Hole finish (RHR)	After coldwork												
¥	Before coidwork												
1	After	0.2495				0.2495				0.2495			
Hole diameter (in.)	After coldwork												
Ť	Before coldwork	0.2390				0.2390				0.2390			
3	(a)	-	2	3	47	_	2	3	4	_	2	3	7
Specimen	g S	-76				11-				8′2-q			

^aTypical hole measurement ^bHole spacing 1:3/8.in. versus 1 in. on –76 and –77

PHASE IL TASK 4 - APPLICATION AND FROM 15 FOR IMPRINT

TEST	NUMBER:	4 G	1

<u> </u>	FN	JE D	ΔI	TPST	CON	DIT	IONS
J	E1,	KE K	46	1631	CON	UII	IVINI

DATE: 4-24-73

1. Specimen Description

High Load Transfer: Fig. 10

Material: 2024-I851

Material Gauge: 0.250"

Surface Treatment: Shot Pean
Fastener: Hi-Lok, Prot. Head

3. Fastener Installation:

Fastener Fit: Net
Installation Torque: 225/250 In/lbs.

2. Hole Preparation

Nominal Hole Size: 3/8"

Process: Ream, C/W, Ream

CW Process: Sleeve

CW Interference: 0.0185"

4. Fatigue Conditions

Net Stress: 30 ksi

Test Load: 16,800 lbs

Load Ratio: R = 0.1

Test Frequency: 600 CPM

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Richie-Los

C/W Net Fit P.H. HiLok .010 Shim

Specimen Ne. R623080	Typical Hole Diameter Before CW (Inches)	Typical Final Hole Diameter (Inches)	Cycles to Failure	Origin of Fallure and Remarks	LOAD
-109	.3545	.3730	580,620	No Surface Fretting	
-110	.3545	.3730	371,350	Origin at 45° to G.	
-111	.3545	.3735	500 ,440	Origin at 45° No surface fretting	

TEST NUMBER: 4 G 2

GENERAL TEST CONDITIONS

DATE: 4-24-73

- 1. Specimen Description
 - High Load Transfer: Fig 10

 Material: 2024 I851

 Material Gauge: 0.250"

 Surface Treatment: Shot Pean

 Fastener: Hi-lok Prot. Head
- 3. Fastener Installation:

2. Hole Preparation

Process: Ream, C/W, ream

CW Process: Sleave

CW Interference: 0.0185"

4. Fatigue Conditions

Net Stress: 30 ksi

Test Load: 16,800 lbs.

Load Ratio: R = 0.1

Test Frequency: 600 CPM

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Riehle-Los

C/W .002 CL. Hilok Prot. Head .010 Shim

Specimen No. R623080	Typical Hole Diameter Before CW (Inches)	Typical Final Hole Diameter (Inches)	Cycles to Failure	Origin of Fallure and Remarks	LOAD
-112	.354 5	.3755	281, 720	Origin at 45° to Q	
-113	.354 5	.3755	291 , 700	Origin at 20° to 1 No surface fretting	
-114	.3545	.3755	355, 200	Origin at 90° to Q No surface fretting	

Some secondary cracks at 45° away from hole on load side.

TEST NUMBER: 4 G 3

GENERAL TEST CONDITIONS

DATE: 4-23-73

1. Specimen Description

High Load Transfer: Fig. 10

Material: 2024 T 851

Material Gauge: 0.250"

Surface Treatment: Shot Peen

Fastener: HI-Lok, Prot. Head

Fastener Installation:

Fastener FIt: _______002" Int.
Installation Torque: ____225/250 in/lbs_____

2. Hole Preparation

Nominal Hole Size: 3/8"

Process: Ream, C/W, Ream

CW Process: Sleeve

CW Interference: 0.0185"

4. Fatigue Conditions

Net Stress: 30 ksl

Test Load: 16,800 lbs.

Load Ratio: R = 0.1

Test Frequency: 600 CPM

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Riehle-Los

C/W Interference Fit HiLok Prot. Head .010" Shim

Specimen No. R623080	Typical Hole Diameter Before CW (Inches)	Typical Final Hole Diameter (Inches)	Cycles to Failure	Origin of Failure and Remarks LOAD	
-115	.3545	.3715	924, 180	ORIGIN AT 0° & NO SURFACE FRETTING	(<u>T</u>)
-116	.3545	.3 715	655, 880	SOME 90° SHANK FRETTING ORIGIN 0° FROM Q. NO SURFACE FRETTING	
-117	.3 545	.3715	900, 530	ASO SHANK FRETTING WAIN ORIGIN OF FROM & NO SURFACE FRETTING	

TEST NUMBER: 4 G 4

(41)	FRAL TEST COMDITIONS	DATE: 4-26-73
1.	Specimen Description	3. Fostener Installatio

Fig. 10 High Load Transfer: 2024 T 851 Material: Material Gauge: _____0.250

Surface Treatment: Shot Peen
Fastener: HI-Lok, Flush Head

2. Hole Preparation

Nominal Hale Size: 3/8"
Process: Ream, C/W. Ream, CSK CW Process: Sleeve CW Interference: 0.019"

astener Installation:

Net Fastener fit: ... Installation Torq in: 225/250 In/lbs

Fatigue Conditions

30 ksi Net Stress: ____ Test Load: 16,800 lbs. Load Ratio: R = 0.1Test Frequency: __600 CPM Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Riehle-Los

C/W Net Fit HiLok Flush Head .010 Shim

Specimen No. R623080	Typical Hole Diameter Before CW (Inches)	Typical Final Hole Diameter (Inches)	Cycl es to Failure	Origin of Failure and Remarks	LOAD
-118	.3545	.3732	508 , 3 60	Origih at 0° to E. No surface fretting	••
-119	.3545	.3732	343 . 460	Origin at 45° to Q. No surface fretting	•••
-120	.3545	.3732	557 , 400	Origin at 45° to Q. No surface fretting	

TEST NUMBER: 4 C 5

GUN	ERAL TEST CONDITIONS	DATE	: 4-26-73
١.	Specimen Description HIgh Load Transfer: Fig. 10 Material: 2024 I 851 Material Gauge: 0.250" Surface Treatment: Shat Peen		Fastener Installation: Fastener Fit: Net fit Installation Tarque: 225/250 In/lbs NO SHIM
2.	Fastener: Hi-Lok (Prot. Head) Hole Preparation	4.	fatigue Conditions 30 ksi
	Nominal Hole Size: 3/8" Process: Ream, C/W & Ream CW Process: Sleeve CW Interference: 0.0185		Net Stress: 30 ksl Test Load: 6,800 lbs. Load Ratio: R=0.1 Test Frequency: 600 CPM Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Righte-Los
	C/W Net Fit HiLok		

Specimen No. R623080	Typical Hole Diameter Before CW (Inches)	iypical Final Hole Diameter (Inches)	Cycles to Failure	Origin of Failure and Remarks LOAD
-121	.3545	.3735	294, 720	SURFACE FRETTING ON LOAD SIDE ORIGINS AT 45° TO G
-123	.3545	.3735	386, 990	SERIOUS SURFACE FRETTING ON LOAD SIDE CRIGIN AT 45° TO & SERIOUS SECONDARY CRACKS IN FRETTING
-123	.3545	.3735	399, 190	ORIGIN AT 0° TO E SURFACE FRETTING ON LOAD SIDE

NOTE: Surface fretting only occurs on load side at first row of holes.

Prot. Head - No Shim

TEST NUMBER: 4 G 6

GEN	FRAL	TEST	COND	ITIONS

DATE: 4-27-73

- 1. Specimen Description
 - High Load Transfer: Fig. 10

 Material: 2024 T B5)

 Material Gauge: 0.250

 Surface Treatment: Shot Peen

 Fastener: Hi-Lok (Prot. Head)
- 3. Fastener Installation:

Fastener Fit: Net
Installation Tarque: 225/250 in/lbs

2. Hole Preparation

Nominal Hole Size: 3/8"

Process: Ream C/W, Ream

CW Process: Sleeve

CW Interference: 0.0185"

4. Fatigue Conditions

Net Stress: 30 ksi

Test Load: 16,800 lbs.

Load Ratio: R = 0.1

Test Frequency: 600 CPM

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Righle-Los

C/W Net Fit HiLok Prot. Head No Shim Upset Removed & Primed

Specimen No. R623080	Typical Hole Diameter Before CW (Inches)	Typical Final Hole Diameter (Inches)	Cycles to Failure	Origin of Fallure and Remarks	LOAD
-124	.3545	.3735	429,000	Main origin at 0° to q. Some surface fretting	
-125	.3545	.3735	674,690	Origin at 900 fold. Some surface fretting	
-126	.3545	.3735	990,370	Origin at 45° to G Some surface fretting	

TEST NUMBER: 4 G 7

GENERAL	TEST CO	DNDI.	TIONS
---------	---------	-------	-------

DATE: _____4-27-73

1. Specimen Description

Ten vig

High Load Transfer: Fig. 10

Material: 2024 T 851

Material Gauge: 0.250

Surface Treatment: Shot Peen

Fastener: Taper-Lok (Prot. Head)

Fastener Installation:

Fastener Fit: Net
Installation Torque: 225/250 In/lbs.

2. Hole Preparation

Nominal Hole Size: 3/8"

Process: Ream only

T/L Prot. Head .010 Shim

4. Fatigue Canditions

Net Stress: 30 ksi

Test Load: 16,800 lbs.

Load Ratio: R = 0,1

Test Frequency: 600 CPM

Test Laboratory: Materials

Test Engineer: D. Reese

Test Machine: Riehle-Los

Specimen No. R623080	Typical Hole Diameter Before CW (Inches)	Typical Head Protrusion (Inches)	Cycles to Failure	Origin of Failure and Remarks	LOAD
-127	-	.230/.250	682,310	ORIGIN AT 90° TO E NO SURFACE FRETTING	••
-128	•	.230/.250	741,500	MAIN ORIGIN AT 45° FRETTING IN FAILED HOLE AT SIDES NO.	SURFACE FRETTING
-129	•	.230/.250	369,400	ORIGIN AT 45° FRETTING IN FAILED HOLE AT SIDES NO	

TFCT	NUMBER.	4 G 8	
1531	INDIANDER: .	* 0 0	

GEN	ERAL TEST CONDITIONS	DAT	F: <u>4-25-73</u>	
١.	Specimen Description	3.	Fastener Installation:	
	High Load Transfer: Fig. 10 Material: 2024 I 851 Material Gauge: 0.250 Surface Treatment: Shot Peen Fastener: Taper-Lok, 100° hec	_	Fastener fit: Installation Torqu	e: _225/250 in/lbs
2.	Hole Proparation	4.	Fatigue Conditions	
	Process: Ream T/L Flush Head .010" Shim	 	Net Stress: Test Load: Load Ratio: Test Frequency: _ Test Laboratory: _ Test Engineer: Test Machine:	16,800 lbs. R = 0,1 600 CPM Materials D, Reese

Specimen No. R623080	Typical Hole Diameter Before CW (inches)	Typical Head Protrusion (Inches)	Cycles to Failure	Origin of Fallure and Remarks	LOAD
-130	~	.230/.250	1,422,370	ORIGIN AT 45° TO Q NO SURFACE FRETTING	
-131	•	.230/.250	517,810	CORKSCREW FRETTING ON SHANK ORIGIN ON 0° TO G. NO SURFACE FRETTING	
-132	-	.230/.250	548 ,000	ORIGIN AT 90° TO Q SOME SHANK FRETTING NO SURFACE FRETTING	

TEST NUMBER: 4 G 9

GENERAL TEST CONDITIONS		DATE:		
١.	Specimen Description	3.	Fastener Installation:	
	High Load Transfer: Fig. 10 Material: 2024 I 851 Material Gauge: 0.250 Surface Treatment: Shot Pean Fastener: Hi-Lok (Prof. Head)	_	Fastener Fit: Net Installation Torque: 225/250 In/lbs.	
2.	Hole Preparation	4.	Fatigue Conditions	
	Nominal Hole Size: 3/8" Process: Drill and ream		Net Stress: 30 ksi Test Load: 16,800 lbs. Load Ratio: R = 0,1 Test Frequenay: 600 CPM Test Laboratory: Materials Test Engineer: D. Reese Test Machine: Riphentos	
			Test Laboratory: <u>Materials</u>	

Reamed Net Fit HiLok Prot. Head .010" Shim

Specimen No. R623080	Typical Hole Diameter Before CW (Inches)	Typical Final Hole Diameter (Inches)	Cycles to Failure	Origin of Failure and Remarks	LOAD
-133	-	.3735	201,290	Origin at 90° to Q	•••
-134	-	.3735	151,220	Origin at 90° ta q No surface fretting	•••
-135	-	.3735	122,060	Origin at 90° to Q No surface fretting	

TEST NUMBER: 4 G 10

١.	Specimen Description	3.	Fostener Installation:	
••	High Load Transfer: Fig 10 Material: 2024 I 851 Material Gauge: 0.250 Surface Treatment: Shot Peen Fastener: Hi-Lok (Prot. Head)		Fastener Fit: Installation Torque: .060 sand blaste	225/250 in/lbs.
2.	Nominal Hole Size: 3/8" Process:C/W_, ream		Fatigue Conditions Net Stress:	16,800 l <u>bs.</u>
	CW Process: Sleeve CW Interference: 0.0185"		Load Fario: F Test Frequency: Test Latoratory: Test Engineer: Test Machine:	Materials D. Reese

Specimen No. R623080	Typical Hole Diameter Before CW (Inches)	Typical final itale Diameter (Inches)	Cyc les to Failure	Origin of Failure and Remarks	LOAD
-136	.3545	.3735	3 65,020	No surface fretting	
-137	,3545	.3735	867,530	No surface fretting	• •

Documents Side	Dr.	/ o o	لية شقق	Opponite Side
				TRESSES ALUMINUM
				STRAIN GAGE READINGS AND CALCULATED STRESSES ALUMINUM

	_		Regimed c	Regimed only fines pres - 0 4 XPr	X + 0 . 94	خ		_	CUNDY	Culdworkes (net area - 0.428)	-0-	é	-	ī	man of ter	DOMO:	Regimed after coldwint installed = 0.410	0.410				Writh Borts metal	- retailing		
	l L	!	 	l !	 							Strein teggineral	CONTRACT LONG	φ, υ: (p											
0.400	دا	3.6	9	8.4	108	3.5	•	0	3.6	0.9	•	901	-	•	3.6	09	8.4	804	0	0	36	6 0 B	7 8	801	, w. 6
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`	27.	130	34/4	7.87	***	2008	5,5	539	1 380	2.650	2.9	3	1,432	3	<u>§</u>	2 482	8	*	- 2.XC	1,721	1973	1 423 2	206	•	Ŕ
۳.	2.	26	×	2.879	182	6	Ē	, o	906	2 785	96 ~	3,218	799	86	1.75	ź	2 747	چ	10.0	1115	15/.	1300		3120	7
4	*		737	908	87.75		1.157	9	268	ž	7817	330	1,210	716	S	2 350	2.836	3 310	1 219	240	1976	7			127
	=======================================	75.			3	2,20	1614	100.6	3.985	**	984	5,314	100	à.	3870	2	20	5 248	CBT.	3,318	986		386	5,311 1 3	3375
٠	-	1.81 1.1.4.	2210	**	16.35	787	1.1.1	\$.	3,670	4 127	878	5 OTB	233	7.59	X	8	4.517		200	- 365	8	. 177 /	671 5	5, 770,	100
٠.	147	. 4.0	766: 0/4. /st	2419	2.84%	1577	ï	£	1.493	1 933	5 16	Ž,	875	370	5	2	2.04	7 0.0 6	÷.	8	184	1 977	7.380	8	ì
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	Ļ	5	1,46,1	19.5.35	1	4	С	0	1100	14 014	19,676	7	0	3	90	# 63#	70 AHA	- in 9	0						-
See of the Paris	Ĺ	8	101	0 - 000 10 M	12	3	0	В	000	10 86	ra Pi	307.61	3	٥	4,400	19 6%	14 333	ίQ 6:	0	0	6.400	10667 1 14	91 1572 AT 1	200	0
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 - -	-	5.00	200	01.2.52 0 25.50 12.550 22.530	27.570	9	01	86	96.9	06.51	98	8	6.70	3	0	09571	17 910 . 2	05- 65	38	0/1:	000	17 110 12	17 2.40 72	27.57.6	ì
^	0	1 1160	044,71	0 1 7 750 17 540 17 440 1	2 240	/ 830	•	5	009	12 300	200	27 140	R	2.	7 730	07971	1, 120 1	22 740	3	ò	1,530	27.030 15	15 15.07] 21	21 780	7.0
7	J	07/4	0/1 11 1/0/19 3	16.030	3,5	0 % T	•	0.71	3,820	065 01	9	02661	097	3	060	007 01	15 160	19 796	26.	011	98.5	9,830 14	14 4 10 18	18.9£C	
•	د 	01/11/080/11/10	11 710	16 420	00/17	0.13	ŏ.	00	3	11 980	200	21.470	2,5	ş	9	11 400	16.680	025.5	01.9	2	9	5 050	-	_	
	3	9 3	1040	15 010	000	6 370	2	063(9)	23 720	047.87	37 670	37.010	16,880	3, 51	12570	7 380	0.75	- 91.2	5 700	2000	25.530 2	28 040 5	20.05.2	 9	-
ت	٥	4, 400	04/01/0004/10			9	٥	18 1900	09.5	015.5	200	3€ 870	18 570	95	24 300	007.00	OUBD	000	3	7 194 61 Z	90.10	2000	A 08.4	410 14	071 61 8
	_	l c. zer.	Ş	07.1	0.00	900	-	740	5510	0156	14 250	10 570	0/3	02.2	0000	01001	16.470	18 680	980	9	2430	•	14 190 18	4	9

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Ti.6Al.4V, 90 split open, 70 ksi		FATIGUE CONDITIONS 70	Max net stress (kst) 20.8	κ ip	Load ratio (R) 4000 cpm	Test trequency Materials	D. Reese	Test engineer 36-kip Vibraphore	Test machine	
ND PROCESS PARAMETERS	623080 DATE 10.3/73	HOLE PREPAHATION	Nominal have size (iii)	Process			FASTENER INSTALLATION	Type	F.1	Torque lin thi
PHASE II-TASK 4- APPLICATION AND PROCESS PARAMETERS	1EST 4A1 SPECIMEN 623080	COLDWORK PROCESS	merter and	Sleeve type	Stewn the knest tin 1	Slewer of ientation	Mandrel material AISI 9260 steel	Manded Laper up /m / 0.045	Mandrel max diameter fin 1	Lubrication
	:	SPECIMEN DESCRIPTION C	Configuration Fig. 2	Marera.	With Lin 1	Hore quering	Estar margon for 1	Material gage (m.) 0.250	Surface treatment Shot peen	

			7			_	7	7			Ţ	7]
. يو		}	٦)		}							
Origin of failure	The Carlo								2		Aba		
0			-				-			>			
			<u> </u>		- -	→ §	T	1	۶	→ ₹	لا	T	-
Cycles	Cycles, to to failure			-	100	87,000			000 02	5	\downarrow		
aze tes t	F. 14		-									-	
Fastener size (10.)	Diameter												
Colitwork expansion (m.)	Retained	0600 0	06000			0.009n	0600 0			0.000	06000		
Col:1 expan,	Actual	0.0180	0.0180			0.0180	0.0180			0.0180	0.0180		
	After	30				30	1			35	1 ;		
Hole finish (RHR)	After	25	:			25	;			25	; 		1
ĩ	Botore	30				35	,			30	-		
	After	0 3745	0 3745			0.3745	0.3745			0 3745	0 3745		
Hole diameter (in)	Africa	0.3640	0.3646			0.3640	0.3640			0.3640	0.3640		
Ho.	Betore	+-				0 3550	03520			03550	03550		
	i o		- -			,-	~	<u></u>	4	_	2	3	0
	Sperine days no		-		!	2	.			ά			

AND PROCESS PARAMETERS Notes and the size in) 0.375 Process Drill (good), C.W. ream Process Drill (good), C.W. ream	APPLICATION / 4A2 (T) SPECIMEN 0.019 Split 0.010	PHASE II - TASK 4- TEST COLDWORK PRI)CESS Interference (in.) Sleeve type Sleeve thickness (in.) Sleeve orientation Mandrel material	Configuration Configuration Material Ti-6At-4V (annealed) Width (in) Hole spacing (in.) Edge margin (in.) 0.75
Type	0.045	Mandrel taper (in /in)	Material (goge (in.). 0.250
FASTENER INSTALLATION	AISI 9260 steel	Mandrel material	(m) 0.75
FASTENER INSTALLATION	AISt 9260 steel	Mandrel material	'
	0°9	Sleeve orientation	g (in.) 1.50
	0.010	Sieeve thickness (in)	1.50
	Split	Sleeve type	Ti-6Al-4V (annealed)
•	0.019	Interference (in.)	1
HOLE PREPARATION		COLDWORK PRINCESS	CRIPTION
		TEST	
AND PROCESS PARAMETERS	APPLICATION	PHASE II - TASK 4 -	
1 61	AND PROCESS PARAMETERS 623080 DATE 10/16/73 HOLE PREPARATION Nominal hole size lin) 0.375 Process Drill (good), C/W, re FASTENER INSTALLATION	SPECIAEN 623080 DATE 1 NOMINAL HOLE PREPARATION NOMINAL HOLE PREPARATION Process Process TYPE TYPE	4

								 				_
Origin of failure	and remarks	w ₂				~~°			*5			
Cycles	failure	63,000				000'99			66,000			
Fastener size (in)	î. I											
Fastener	Diameter											
Coldwork expansion (in.)	Returned	0.0100	0.0100			0.0100	0.0095		0.0100	0.0100		
Cold	Actual	0.0180	ì			0.0180	l		0.0180	1		
1)	After ream	30				30	1		30	,		
Hole finish (RHR)	After coldwork	30	ı			30	i		30	1		
Ĩ	Before coldwork	55	:			55			55	I		
	After	0.3750	0.3750			0.3750	0.3750		0.3750	0.3750		
Hole diameter (in)	After coldwork	0.3650	0.3650			0398:0	0.3650		0.3650	0.3650		
H ₂	Before	0.3550	0.3550			0.3550	0.3555		0.3550 0.03550 0.03550 0.03550			
=	a or	_	2	3	4	-	2	4	•	2	٣	4
Specimen	das, or	Ą				κį			بو			

Ti.6Al-6V. C/M, abusively drilled hole, 70 ksi		Max net stens tks: Max test load (kip) Load ratio (Ri) Test frequency Test taboratory Test engineer Test machine Test machine 36-kip Vibraphore	
1-TASK4 - APPLICATION AND PROCESS PARAMETERS	623080 DATE 10/16/73	HOLE PREPARATION Nominal hole size (in) 0.375 Process Orill (abusively) C/W, ream Process Type FASTENER INSTALLATION	Torque (in lb)
PHASE II -TASK4 - APPLICATION A	TEST 4A3 (T) SPECIMEN 623080	COLOWORK PHOCESS Interference (in.) Steeve type Steeve type Steeve type Steeve orientation Steeve orientation Steeve orientation Mandret material Mandret man diameter (in.) 0.045	Fel Pro 300
		Configuration Fig. 2 Configuration Ti-6AL4V (annealed) Material Edge margir (in.) 1.50 Material gage (in.) 0.250 Material gage (in.) Shot peen	

	Origin of failure and remarks		→ 3					•			}	-	CW					
	Cycles 5	failure	47 000					43,000				64 000	3				1	
1 (11) 3715		Ē												-		\ 		
Factories Size (in)		Diameter											1					
Coldwork	expansion (in)	Retained	0000	0.0030	0600.0			2000	2000.0	0.0085		-+-	0.0080	0.0070		 		
9	expairs	Actual		0.0165	0.0160				0.0160	0.0160			0.0150	0 0140		1		
	= =	Alter	1	30	i		-		8	1	-		30	!	 			
	Hale finish (RHR)	After		40	i				45				45	-	\ \ +	-		
	Hol	Before		65					65	70			75	 		-		
-		A	wpal	0.3750	03750				0.3750	0.3750			0.3750	0.3750	2	-		
	Hole diameter (in.)	After	COLIMOTE	0 3655	1	i			0.3655	0.3655			03560	0.36.60	0.3000		-	
	Hol	gutore	CORGWOAP	0.3565	T	1			0.3570	0.3570			0.3580	0.5500	0.3590			
		: o		_	,	, , ,	¬	4	-	2	<u>س</u>	4	-	. ,	~ -			
		Specimen dash no		,	,				æ	,			,	j.				

PHASE II - TASK 4 - APPLICATION AND PROCESS PARAMETERS

SPEC-MEN 623080 DATE 10/3/73

16ST____

Ti-6AI-4V, C/W open, no postream, 70 ksi

·	70	20.5	10	4000 cpm	Materials	D. Reese	36-kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ks.) 70	Max rest load (kip) 205	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	0.375	Ream, C/W			2			
MOLE PREPARATION	Nominal hole size (in.)	Process			FASTENER INSTALLATION	Type	Fig	Torone (re. 1b)
	6100	Split	0.010	000	AISI 9260 steel	0.045	0.353	Fel Pro 300
COLDWORK PROCESS	Interterence (in.)	Sleeve type	Sleeve thu kness (in)	Sleeve Offentation	Manurel material	Mandrel taper (in (in.)	Mandrel max diameter (in)	Lobrication
	Fig. 2	Ti 6At 4V (annealed)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Canfiguration	Material	Width (in)	Hale spacing (in.) 1.50	Edge margin (in.)	Material gage Im }	Surface treatment	

19 10 000	and remarks		CW			\{\begin{align*}			}		w ₂		
Çel s	10 failure	79.000				88,000				82,000			
Fastener size lin)	Fit												
Fastener	Diameter												
Colifwork expansion fin)	Retained	0600.0	06000			0.000.0	0.0000			0.0000	0.0000		
Cofe	Actual	0.0100	0.010			0.0190	0.0190			0610.0	0.0190		
	After	35	i			35] 	 		30	j -		
Hole Linish (RHR)	After	20	'			20	í			20			
Ĭ	Before	35	-			35	1			35	;		
	After	0.3745	0.3745			0 3745	0.3745			0.3745	0.3745		
Hole diameter (in.)	After	0.3630	0.3630			0.3629	0.3630			0.3630	0.3630		
Ĭ	Before	0.3540	0.3540			0,3540	0.3540			0.3540 0.3540 0.3540 0.3540			
101		-	2	3	4	-	2	3	4	-	2	٣	4
Specimen	dash OO	10		<u> </u>		11				12			

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Ti-6AI-4V. C/W open, scored, 70 ksi

\	S.	70	20.4	0.1	4000 cpm	Materials	D. Reese	36-kip vibraphore	
/0 ksi	FATIGUE CONDITIONS	Maxinet stress (ksi)	Max test load (kip)	Load ratio (A)	Test frequency	Test laboratory	Test engineer	Test machine	
DATE 10/3/73	z	(in) 0.375	Ream, C.W. ream, score, one hole			LATION			
SPECIMEN 623080 DATE	HOLE PREPARATION	Nominat hale size (in)	Process			FASTENER INSTALLATION	Tvo	Fit	Torone (in tb)
TESTSPECIMEN		0.019	Split	0.010	00,	AISI 9260 steel	0.045	0.353	Fel Pro 300
TEST	GOLDWORK PROCEUS	Interference (in.)	Sleeve type	Sleave thickness (in 1	Sleeve of entation	Mandrel material	Mandrel taper (m 'm)	Mandrel max diameter (in)	
	IPTION	Fig. 2	Ti-SAI 4V (annealed)	1.50	1.50	0.75	0.250	Shot peen	
	SPECIMEN DESCHIPTION	Configuration	Material	Width	Hole spacing (in.)	Edge margen lin)	Material upge (in)	Surface treatment	

Origin of failure	and remarks	c.w			Failed in scored hole				Failed in scored hole				Failed in scored hale
Cycles	failure	85,000				72,000				76,000			
Fastener size (in)	f.t												
Fastener	Diameter												
Coldwork expansion (in)	Retained	0600.0	06000			0.0095	0.0095			0600.0	U600 0		
Colo	Actual	0.0100	06100			0.0190	0.0190			0.0190	0.0190		
	After	35				35	1			35	:		
Hale finish (RHR)	After	20				50	, - -			20			
H	Butorr	35	,			35	•			35	i	 -	
_	After	0.3745	0,3745			0.3745	0.3745			0,3745	0.3745		
Holy diameter (m.)	After	0.3630	0.3630			0.3635	0.3635			03630	0.3630		
Î	Before ocidwork	0.3540				0.3540	03540			0.3540	0.3540		
	Hotel Se	-	2	3	4	_	2	3	4	-	~	 ~] ! .,
9	dash	13				14				-15			

PHASE II - TASK 4 - APPLICATION AND PROCESS PARAMETERS

Ti-6AI-4V, open, 1/64 postream, 70 ksi

	SZ	70	20.2	0.1	4000 cpm	Materials	D. Reese	36-kip Vibraphore	
	FATIGUE CONDITIONS	Max net stress (ksi) 70	Max 11-51 10ail (kip) 20.2	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
2/73		0.375	Ream, C/W, ream.	1/64 oversize		ZC			
SPECIMEN 623090 DATE 10/12/73	HOLE PREPARATION	Nomasi hale see (m.)	Pioress			FASTENER INSTALLATION	Type	F.1	Torque (m. 1b)
1		0.019	Split	0.010	0,0	AIS! 9260 steel	0.045	0.353	Fel Pro 300
TEST 4A6	COLDWORK PROCESS	Interference (10.)	Steeve type	Slimur thickness fin !	Sleeve or entation	Mandret material	Mandrel taper (in lin)	Mendrel max diameter (in)	Lubrication
	SPECIMEN DESCRIPTION	Configuration Fig. 2	Material Ti-6At-4V (anneated)	Width Lin 1	Hote spacing (in.) 1.50	Erige margin lir) 0.75	Material gage In J	Surface treatment Shot peen	

Common of Ballices	and remarks		CW			}	W.C.			→				
Cycles	to facture	61,000				64,000	 			64,000				
f asterner sizer (en f	For													
Fastimer	Diameter													
Coldwork engassion ton 1	Retained	0.0095	0.0095			0600.0	0.0000			0.0095	9600.0			
Col	Actual	0.019	0.019	 		0.019	9100			0.019	0.019	 		
æ	Atter	40				45				45	!	<u> </u>		
Hole Laush (RHR)	After	20	***			20				22				
Ī	Biltore	35	ī			35	ı			35	ı	 		
-	Afree	0.3900	0.3900			0 3900	0 3900			0 3900	0 3900			
Hate barnetin bir	After Coffwork	0.3635	0.3635			0.3630	0.3630			36.35	0 3635			
Ĭ	Betore costwork	0.3540	0.3540			0.3540	0.3540 0.3630			0.3540				
<u> </u>	ş	-	2	8	4	-	2	3	7	-	2	3	4	
Sper impri	ç	16				.17				81.				

PHASE II -TASK4 - APPLICATION AND PROCESS PARAMETERS

NAMETERS Treated open, 1/32-postream, 70 ksi

TEST 4A? SPECIMEN 623080 DATE 10/12/73

	76	20	0.1	4000 cpm	Materials	D. Reese	36 kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ks.)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	0.375	Ream, C/W, ream,	37:00ers12e		2			
HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Fit	Torque (in (b)
	0.019	Split	0.010	0,	AISI 9260 steel	0.045	0.353	Fel Pro 300
COLDWORK PROCESS	Interference (4D.)	Steeve type.	Steeve thickness (in)	Sleeve or innitation	Mandrel material	Mandrel taper (in 'in.)	Mandret max diameter (in)	Lubrication
	Fig. 2	Tr6AL4V (annealed)	1 50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material	Width (c)	Hole stateing (In.) 1.50	Erige margin (in 1	Material gage (in.) 0.250	Surface treatment	

Origin of failure	and remarks	→ 33				- W				→ V			
Cycles	faiture	54,000				76,000				000'.29			
Fastener size (in)	Fit												
Fastener	Diameter												
Coldwork expansion (in)	Retained	0.0000	06000			0600 0	0600.0			0 0095	0 0095		
Colo	Actual	0.019	0.019			0.019	0.019			0 0 19	0.019		
	Atter	30	1			30				90	<u>'</u>		
Hole Linish (RHH)	After	20	-			15				15	1		
1 =	Butore	35	1			35	-			35			
-	Alter	0 4065	0 4065			0.4065	0 4065			0 4065	0 4065		
Hole diameter (in)	After	0.3630	0.3630			0.3630	0 3630			0 3635	0 3635		
H L	Before	0.3540	0 3540			0 3540	0 3540			0.3540	0 3540		
	<u>.</u>	-	~	8	4	-	2	3	4	-	~	m	4
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)	TIONS	70	19.4	0.1	4000 cpm	Materials	D. Reese	36-kip Vibraphore	
	FATIGUE CONDITIONS	Max net stress (ks.)	Max test load (kip) 19.4	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
12/73		0.375	Ream, C/W, ream	1/16 oversize		2			
SPECIMEN 623080 0ATE 10/12/73	HOLE PREPARATION	Nominal hole size (in.)	Process			FASTENER INSTALLATION	Type	Fit	Torque (in 1b)
ı		0.019	Split	0.010	00,	AISI 9260 steel	0.045	0.353	Fet Pro 300
TEST 4AB	COLOWORK PROCESS	Interference (IA.)	Steeve type	Steeve thickness (in.)	Sleeve Orientation	Mandrel material	Mandret taper (in (in)	Mandrel max diameter (iii) 0.353	Lutxicstion
	NOILION	Fig. 2	Ti-6Al-4V (annealed)	1.50	1.50	0.75	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Material	Weth tin !	Hole spacing (in.)	Edge margin lin)	Material gage lin 3 0.250	Surface treatment	

Orange of failure	and remarks	-	C/W			{	wo [{	C·W		
Cycles	to farture	62,000				67,000				54.000			
Fastener size In]	ū												
Fastener	Diameter												
Coldwork expansion (in)	Retained	06000	0600.0			0600 0	0.000.0			060000	0600.0		
3 60	Actual	0.019	0.019			0.019	910.0			6:00	0.019		
. ≈	Atter	45				45	;			45	1		
Hale finish (RMR)	after	25	:			20				20	ı		
Ĭ	Before	35	-			35	1			35	-		
,	After	0.4380	0 4380			0 4380	0 4380			0 4380	0 4380		
Hole diameter (in)	After coldwork	0898 0	0 3630			03630	0.3630			0.3630	03630		
3 43	Before coldwork	0 3540	0 3540			C 3540	C 3540			C 3540	C 3540		
a O I	5.	-	2	3	4	-	2	3	4	-	2	3	4
Specimen	or or	22				23				24			

PHASE II - TASK4 - APPLICATION AND PROCESS PARAMETERS

Ti-6A1 4V. square wire sle

)	TIONS	ke,) 70	Not tested	0.1	Not tested	Not tested	Not tested	Not tested	
70 ksi		FATIGUE CONDITIONS	Max net stress (kg)	Max fest load (Its)	Load ratio (R)	Test frequency	Test taboratory	Test engineer	Test machine	
	2/73		0.375	Ream, C/W, ream			•			
	623080 DATE 10/12/73	HOLE PREPARATION	Nominal hole size (in.)	Process			FASTENER INSTALLATION	Type		Torque (in 11)
	4A9 SPECIMEN 623080		610.0	Square wire	0.018		AISI 9260 steel	0.045	0.353	Fel Pro 300
	TEST_4A9	COLOWORK PROCESS	toterference (Iff.)	Strewe Type	Sleeve the kness (in)	Sterve orientation	Mantrel material	Mandrel (april 1117/101)	Mandrel max diameter (iii.) 0.353	Lubrestion
		PTION	F19.2	Ti 6Al 4V (annealed)	1 50	1 50	0.75	0 250	Shot peen	
		SPECIMEN DESCRIPTION	Configuration	Water is!	Width (in)	Hole spating (in.)	Edge margin (in)	Material gage (in)	Surface treatment	

Origin of failure	and remarks	}								{			
C, cles	farlure		u _z										
Fastener size (in)	۴،۱		- "	Jacks Burk								: : : : :	
Fastener	Diameter				OMOIO3 O	" Parlulis"						į	
Coldwork expansion (in)	Retained		j			و درس	يو باهمار						
o) (O)	Actual						- §	Savare	0.				
ā	Atter								a aldino	ا رد		! 	
Hole finish (RMR)	After coldwork									07			
Ī	Before	30				30				35			
_	After												
Hob-diameter (in)	After coldwork												- 1
ξ ξ	Before	0.3715	0.3715			0.3715	0.3715			0.3715	0 3715		
į		-	2	~.	4	~	2	3	4		2	3	4
Specimen	de de	25				92				27			

PHASEII -TASK4 - APPLICATION AND PROCESS PARAMETERS

Ti-6A14V. 0.060 in. gage mtl 70 ksi

TEST 481 SPECIMEN 623080 DATE 10/3/73

36-kip Vibraphore 4000 cpm D. Reese Materials 2 FATIGUE CONDITIONS Max net stress (ksi) Max test load (kip) Test laboratory Load ratio (R) Test frequency Test ingineer Test machine Ream, C/W, ream 0.375 FASTENER INSTALLATION Nominal hole size (in 1 HOLE PREPARATIO' Torque (in ilb) Process Type F AISI 9260 steel Fel Pro 300 0.010 0.045 0.019 Mandrel max Jiemeter (in). 0.353 Split Mandrel taper (in /in) Steeve thickness (in.) COLDWORK PROCESS Steeve orientation Interference (in.) Mandrel material Sleeve type Lubrication Ti-6Al-4V (annealed) Shot peen F.19. 2 0.00 1.50 1.50 0.75 SPECIMEN DESCRIPTION Material gage (in). Hale spacing (in.) Edge margin (in) Surface treatment Configuration Width (in) Material

Origin of failure	and iemerks	- 80								- NO.			
Cycles	fariore	61,000				50.000				61,000			
Fastener size (in)	Fit												
Fastener	Diametire												
Colitwork expansion (in)	Retained	0.0080	08000			0800.0	0800.0			0.0085	0.0085		
Substance of the control of the cont	Actual	0.0185	0.0185			0.0185	0 0 185			0 0185	0.0185		
=	After	25	i			5.5	'			25	'		
Hole finish (RHR)	After	15	_			10	:			15	!		
H	Refore coldwork	75	.			25	i			25	1		
	After	0 3745	0.3745			03745	0.3745			0 3745	0 3745		
Hole diameter (in)	Afrer	0.3625	0 3625			0 3625	0 3625			03630	0 3630		
Ŷ	Before	0 3545	0 3545			0 3545	0.3545			0.3545	0.3545		
	1011	-	2	3	4	_	2	3	7	-	2	3	4
() ()	- F	28				56				30			

Ti-6A1.4V one hole, C/W, 70 ksi	FATIGUE CONDITIONS	Max net stress (ks) 70 Max rest load (kip) 20.5	Load ratio (R) 0.1 Test frequency 4000 cpm	Test laboratory Materials Test engineer D. Reese	36-Vibraphore
اامتما	TACT SPECIMEN 623080 DATE 10.47.73		Material Ti 6AI 4V (annealed) Sierve type 0.010 0.010 sierus thickness (in) 0.010 Sierus thickness (in) 0.010	q(m.) 1.50 Steeve arentation AISI 9260 steel FA	Material gage (ini.) 0.250 Manifred taper (ini.) 0.353 Fit Net to 0.005 Clearance Surface treatment Shot peen Mandrel max diameter (ini.) Fel Pro 300 Torque (ini.tb) 240.250

_	_						_	_	Т		_	_	<u> </u>	\neg		_		_			
	Origin of failure	and remarks			P			alog possession in the	Failed in reamed role	- 3	()			Failed in reamed hole	-	} ¥			Failed in reamed hole		
	Cycles	0,	failure		119,000			-		7,000	330,1,1					11,286,000			+		
	Fastener size (in)		F. 1		0.3740	0.0005	2000	1		1,000	2000	0.0005		-	1	90000	0.0005	 	-	-	
	Fastener		Diameter		0.3740	00000	0.57.40				0.3740	0.3740				0 3740	0.3740	-			
1	Coldwork	expansion in l	Hetamed		0 0095		-				0.0095	\ \ \		-		0.0095					
	P ₁ O ₂	Suedia		3010	0.0191,		-				00100	 		-		00100	2	<u></u>	-		
			After	ream	۶	3					25					,		-	_		
	gradi i	HOW LINISH (MHK)	1	coldwork	{	2					ç	3	,				50				
		Hol		Batore coldwork		35	. !				,	£	:				35	-			
				Atter		0 3745	0.3745					0 3745	0.3745			+	0 3745	0.3745			
		Hote thameter find		Atter	CO1 1000	0.3635						0 3635	:				0 3635		<u> </u>		
		HOH		8-fore	condimor	0 3540						0 3540	:				0 3540	<u> </u>	-	+	-
			al Dir	ou Ou		-	2	7		4		-	~	m		٠	-	^		·	4
				2 2		~		1				32					33				

36-Vibraphore 4000 cpm Materials D. Reese Ti-6AI-4V, C/W, 0.002 clearance Hi-Lok.) 20.5 FATIGUE CONDITIONS Max net stress (ksi) Max test load (kip) Test laboratory Load ratio (R) Test frequency Test engineer Test machine Ream, C/W, ream Hi-Lok, prot hd 0.002 clearance PHASE II -TASK4 _ APPLICATION AND PROCESS PARAMETERS 0.375 240.250 DATE 10/15/73 FASTENER INSTALLATION Nominal hole size (in.) HOLE PREPARATION Torque (in. ib) Process F., (in.) SPECIMEN 623080 Type AISI 9260 steet Fel Pro 300 0.045 0.019 0.010 Manchel max diameter (in.) 0.353 Split TEST_4C2 Mandrel taper fin /in) Sleeve thickness (in.) COLDWORK PROCESS Sleeve orientation Interference (ID.) Mandrel material Sireve Type Lubrication Ti-6Al-4V (annealed) Shot peen F19. 2 0.250 0.075 55 1.50 SPECIMEN DESCRIPTION

Hale spacing (in.) Edge margin (in) Material gage (in) Surface treatment

Width (in) Materia!

Configuration

Orien of tailure	and remarks		C/W Hd				C.W		}	-	C/W Hd		
Cycles	10 farlute	153,000				226,000				179,000			
Fastones saze (in)	<u> </u>	0.00	0 002			200 0	0 002			0 002	0 005		
Fastene	Diameter	0.3735	0.3735			3575.0	0 3735		:	0.3735	0.3735		
Coldwork expansion (in)	Resained	0.010	0.0110			0.0105	0.0105			0.100	0.0095		
Col	Actual	0.0190				0.0190	_			0.0190			
18	HIP	30	1			30	_		!	30	;		
Hole finish (RHR)	Afrer	15	ı			15	_			15	_		
Ĭ	Before coldwork	35	ı			35				35			
	After	0.3755	0.3755			0.3755	9.3755			0.3755	0.3755		
Hole diameter (in }	After	0:3630	0.3630			0.3625	0.3625			0.3630	0.3635		
Ĭ	Before coldwork	0 3540	0.3540			0.3560	0.3550			0.3560	03560		
- 0 1		-	2	3	4	-	2	3	4	-	2	3	4
Specimen	no n	34				35				36			

Market State Commence of the control

PHASE II - TASK 4 - APPLICATION AND PROCESS PARAMETERS

C/W, 0.002 interference, Hi Lok

TEST. 4C3 SPECIMEN 623080 DATE 10/15/73

10	70	20.2	0.1	4000 cpm	Materials	D. Reese	36 Vibraphore	
FATIGUE CONDITIONS	Max net stress (kss)	Max test load (kip)	Load ratio (R)	Test frequency	Test taboratory	Test engineer	Test machine	
	0.375	Ream, C/W, ream			TION	Hi Lok prot hd	0.002, interference	240 250
HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	F. (in.)	Torque (in 1b)
	0.019	Split	0.010	0,	AISI 9260 steel	0.045	0.353	Fel Pro 300
COLOWORK PROCESS	Interference (ID.)	Sleeve type	Steeve thickness (in)	Sleeve orientation	Mandett material	Mandrel taper (in /in.)	Mandrel max diameter (m.) 0.353	Eubricition
FION	Fig. 2	Ti-6Al-4V (annealed)	1.50	1.50	0 75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	•	Width (m.)	Hole specing (ID.)	Edge margio on I	Material gage fin l	Surface treatment	

Origin of failure	and remarks	→ I	40			FH H							
Cycles	faiture	4,421,000				6,836,000				824,000			
Fastener size (in)	F.:	0.002	0 005			0.002	0.002			0.002	0.002		
Fastene	D-ameter	0 3735	0 3735			0.3735	=			0.3/35		İ	
Coldwork expansion (-n.)	Retained	0.0110	00100			0.0100	0.0100			00100	0.110		
Cole	Actual	06100	06100			0.0190	06100			40 0 0190	0.0190		
11	After	30				30	:			40	<u> </u>		
Hole fraish (RHR)	After roldwork	15	-			15				15	'!	! :	
ž	Buforn coldwork	35	!			35	i			35			
	After	0.3715	0 3715			0.3715	03715			0.3715	0.3715		
Hole dameter (in)	A*1++ colifwork	0.3620	0.3630			0 3630	0 3630			0.3620 0.37.5	0 3620		
Ho	Before	0.3540	0.3540			0.3540	0.3540			0.3540			
	0 p	-	2	3	4	-	2	3	4	-	-2	<u>س</u>	\ *
	ngeb or	537				38				39			

APPLICATION AND PROCESS PARAMETERS	
AP	
1	
70.7	ĺ
<u> </u>	
TASK4	
C	

Max net stress ths	0.375	Nominal hole size lin.)	0.019	Interference (in.)	
FATIGUE CONDITIE	,	HOLE PREPARATION		COLDWORK PROCESS	
	<u> </u>	SPECIMEN 623080 DATE 10/17/73	TEST 4C4 SPECIMEN	TEST	
Ì					

NS.	70	20.5		4000 cpm	Walter tois	D. Heese	36-kip Vibraphore	
FATISCE CONDITIONS	Man net stress than	Max test load (kip) 20.5	Load ratio [R]	Tess frequency	Test taboratory	Test engineer	Test machine	
	0.375	C/W, ream, csk			TION	Hi Lok 100-hd	Net to 0.0005 clearance	240.250
HOLE PREPARATION	Nominal hole size lin.)	Process			FASTENER INSTALLATION	Туре	Fit (in.)-	Torque tin 16)
	0.019	split	0.010	0,	AISI 9260 steel	0.045	(m) 0.353	Fel Pro 300
COLDWORK PROCESS	Interference (in.)	Sleeve type	Steeve thickness (in)	Steme onentation	Mandre: material	Mandrel taper (in Jin.)	Mandrel max diameter (iii) 0.353	Lubricstian
	CKIETIUM Fig. 2	Ti. BAt 4V (annealed	1.50	(in.) 1.50	0 75	0.250	Shot peen	

	Origin of failure	and renders	H Hd		3		C.W		}	4	LCW Hd]	
	Cycles	tailuse	217,000			212 000	30				483,000			
	Fastener size tin i	F.:1	0.0005	0 0000		3000	coord	0 00005	1		0 0005	50000	-	
	Fastener	Diameter	0.3745	0.3745		3	7. 15	0 3745			0 3745	03745		
California k	expansion (H.)	Hetained	0.0085	0.0085			0.0085	0.0085			0 0075	0 0075		
3 8	expans	Actual	0.0185	0.0185			0.0185	0.0185	-		0.0185	0.0185		
	3	After	90	!			8	-			8	-	_	
	Hale foush (RHR)	After	20	,			20	:			20			_
	Ĭ	Before	35	,			35	1			35	1		
		Alter	03750	03750			03750	03750			0.3750	03750		
	Hole dismeter (in)	Afree	0 3630	0.3630	}		03630	0.3630			0.3620	0 3620		
	H _O	Setore	0.3545	0 3545			0 3545	0.3545		 	0.3545	1		
		Hole or	-	۲.	3	प	~	2	۳	4	-	2	~	4
		Spik imen dash no	Ş	3				·			25	, 		

SPECIMEN DESCRIPTION

Hole spacing (in.)

Width (in) Materia

Material gage (m.) Surface treatment

Edge margen (m.)

APPLICATION AND PROCESS PARAMETERS
PHASEII -TASK 4

Ti-6AI-4V, 100° csk before C/W, 70 ksi

TEST_4C5 SPECIMEN 623080 DATE 10/17/73

Š	70	20.1	0.1	4000 cpm	Materials	D. Reese	36-kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	. Test frequency	Test laboratory	Test engineer	Test machine	
HOLE PREPARATION	Nominal hole size (in). 0.375	Process Csk, C/W, ream			FASTENER INSTALLATION	Type. Hi-Lok flush fid	Fit (in.) Net to 0.0005 clearance	Torque (in. 1b) 240.250
	0.019	Split	0.010	00	AISI 9260 steel	0.045	0.353	Fel Pro 300
COLDWORK PHOCESS	interference (in.)	Sireve type	Sieeve thickness (in.)	Sleeve orientation.	Mandrel material	Mandrel taper (in./in.)	Mandrel max diameter (m.) 0.353	Lubrication
PTION	Fig. 2	Ti-6Al-4V (annealed)	1.50	1.50	0.75	0 250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Vister a	Width fin i	Hole spacing (In.)	Edge margin (in.)	Material gage I.n.)	Surface treatment	

Orgin of falure	and remarks		C/W		}		C/W Hd		}		C.W		
Cycles	to failure	760,000				757,000				1,064,000			
Fastener size (in.)	Fit	0.0005	0.0005			0.0005	0.0005			0.0005	0.0005		
Fastener	Diameter	0.3740	0.3740			0.3740	0.3740			0.3740	0.3740		
Coldwork expansion (in.)	Retained	0.0085	0.0000			0600.0	0600.0			0.0000	0.0000		
Cole	Actual	0.0180	0.0185			0.0185	0.0185			0.0185	0.0185		
æ	After	20	1			50	+		ļ 	20	ı		
Hole finish (RHR)	After coldwork	10	l			10	!			10	:		
Ĭ	Before coldwork	30	I			30	1			30	1		
-	After	0.3745	0.3745			0.3745	0.3745			0.3745	0.3745		
Hole diameter (in)	After cortwork	0 3635	0 3635			0.3635	0 3635			0 3635	0.3635		
JH	Before	03550	0 3545			0 3545	0 3545			0 3545	0 3545		
; 1	o,	-	2	ć:	77	1	2	3	4		2	c:	*7
Specimen	de Cr	43				44				45			

PHASE II -TASK4 __ APPLICATION AND PROCESS PARAMETERS

TEST 4C6 SPECIMEN 623080 DATE 10/17/73

Ti 6A14V, 70° cst after C/W, 70 ksi

s 20	20.5	0.,	4000 cpm	Materials	D. Reese	36-kip Vibraphore	
FATIGUE CONDITIONS Max net stress (ks.)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
0.375	C/W, ream, csk			FASTENER INSTALLATION	Boeing radius lead in bolt, 70° hd	Net to 0.001 interference	(in Ib) 240.250
HOLE PREPARATION Nominal hole size (in	Process	1	ı	1	Type		Torque (in Ib)
0.019	Split	0.010	00	AISI 9260 steel	0.045	, 0.353	Fel Pro 300
COI DWORK PROCESS	Sleeve type	Sleeve thu kness (in)	Sleeve of entation	Manufel material	Mandrel taper (in /in.)	Mandrel max diameter (iii)	Lubricstion
CRIPTION Fig. 2	Ti 6Al 4V (annealed)	1.50	(in.) 1.50	0.75	10.15	Shot peen	
SPECIMEN DESCRIPTION	Material	Width in 1	Hole spacing (In.)	Elige margin (in)	Waterial page lin l.	Surface treatment	

Origin of faiture	and remarks	- ₹				- - - - - - - - - - -				- 3			
		- - ₹	<u></u>]		1	<u>.</u>]		← ₹] 	
Cycles	to factre	555,000				570,000				435,000			_
Fastener size (in.)	Fit	0.001	0.001			0.001	0.001			0.001	0.001		
Fastener	Diameter	0.3800	0.3800			0.3800	0.3800			0.3800	0.3800		
Coldwork expansion (in)	Retained	0.0075	0.0075			0800.0	0.0080			0.0075	0.0075		
Cold	Actual	0.0185	0.0185			0.0185	0.0185			0.0185	0.0185		
æ	After	30	,			30	!			30	,		
Hole finish (RHR)	After coldwork	20	1			20	٠			20	1		
₹	Before coldwork	35	ł			35	-			35	1		
_	After	0.3790	0.3790			0.3790	0.3790			0.3790	0.3790		
Hole diameter (m.)	After	0.3620	0.3620			0 3625	0 3620			0.3620	0.3620		
£	Before	0.3545	0.3545			0 3545	0.3545			0.3545	0 3545		
	ğ ç	-	2	8	47	-	2	3	4	-	2	3	4
Sperimen	1 20	46				47				£ 1 .			

36-kip Vibraphore 4000 cpm O Reese Materials Ti-6Al-4V, prefatigue, C/W, net-fit Hi-Lok, 70 ksi FATIGUE CONDITIONS Max test load (kip) Max net stress (ksi) Load ratio (H) Test laboratory Test frequency Test machine Test engineer Install fastener, fatigue 80,000 cycles ream, C/W, ream Hi-Lok, prot hd Ream undersize, Net to 0.0005 clearance APPLICATION AND PROCESS PARAMETERS 240.250 0.375 11/16/73 FASTENER INSTALLATION Nominal hole size (in l HOLE PREPARATION DATE Tarque (in 1b) F.11(10.) Process 1 y 1 x SPECIMEN 623080 AISI 9260 steel Fel Pro 300 0.045 Mandrel man chameter Icn.) 0.353 0.010 6100 Split TEST_4C7(T) PHASEII -TASK4 -_ Mandrel taper (in 'in) COUDWORK PROCESS Spear the knews (m.) huerteener (m.) Sleeve Oresitation Manifest material Lubrication Steen 1ype Ti 6Al 4V (annealed) Shot peen 0 250 Fig. 2 1 50 0.75 1 50 SPECIMEN DESCHIPTION How specing (in.) Surface renatment Material gage Lin I Eugenmargen tin 1 Water and Atlater is

	Origin of families							__	C/W Hd				-	C/W Hd				
	CVC!53	failure	-					209 000	Т				431,000					
- L n.) +/10		ī.						ž		Net			ž		ا ا ا		 - -	
Fastener size (in l		Diameter						30700	0.3733	0.3735			A 27.25	56.60	0.3735		i 	
40th	, uni id	Retained	+			-		1	0.0095	0 0095			_	_	0.0095			
Coldwork	un nosuedira	Actual		-					00100	00100				00100	0.0190		<u> </u>	
	â	Alter	1100				1		52			-	-	25	. !	-	1	_
	HOLF finish (RMR)	After	Colebour b						5	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	-			15	,		-	
	Î	Belate	4.000-10.0			1			8		-			30	! ! !			
-		After	wPas		-	1			0.3735	,	0 3735			0.3735	0.3735	+	-	
	Hour Lameter for I	2114	Constant William	1	÷ -				0.3636	Croc o	0 3635			0.3635	1 1 2 2 0	1 1 1 1	· · · · · ·	
	*****				-				l	U 3540	03540			0.36.40	1	0.540		· · · ·
		<u> </u>		-	,	, 	~	4		-	C,	3	.,	-		.	e1	
		Sperimen.	 ë	100						20];	[5]			

والاستخفاف المالهافة لالاداسا

PHASE II -TASK 4 - APPLICATION AND PROCESS PARAMETERS

Ti-6AI-4V. precracked, C/W, net-fit Hi-Lok, 70 ksi

36-kip Vibraphore Materials 4000 cpm D. Reese FATIGUE CONDITIONS Max test load (kip) Man net stress (ksi) Load ratio 1A) Test laboratory Test frequency Test engineer Test machine notch, fatigue rack, ream, C/W, ream Ream undersize, Hi-Lok prot hd Net to 0.0005 clearance 240.250 0 375 DATE 11/16/73 FASTENER INSTALLATION Nominal hole size (in) HOLE PREPARATION F., (in.) Process SPECIMEN 623080 Type AISI 9260 steel F41 Pro 300 0.045 0.010 9.019 Mandrel max diameter (in) 0.353 TEST 4CB (T) Split Mandrel taper fin (in) COLUMORK PROCESS Sleeve thu units fin I Interference (In.) Sieeve or ientation Mandret material Sieeve type Ti 6A! 4V (annealed) Shot peen 0.250 F19. 2 1 50 3 0.75 SPECIMEN DESCR PTION Hote spacing (In.) Surface treatment Material gage (in) Edge margin in !

Configuration

Width (in) Nater a

Torque (in 1b)

Lubrication

Origin of failure	and remarks		PH F		0.020 in crack remaining after ream		PH (0.030 in crack remaining after ream	{	PH	Enited at hole no. 2.	0.010 in crack remaining after ream
Cycles	failure	312,000	<u></u>		00	92.000	<u></u>]]	00	782,000	3		0.0
(u) 42)	F.1	N et	Net			Net	Net			Net	Net		
Fastener size (in	Olameter	0.3735	0.3735			0 3735	0.3735			0.3735	0 3735		
Coldwork expansion (in)	Retained	0.0095	0.0095			0.0095	9600.0			0.0095	0.0095		
Co ^l d expensi	Actual	0.0190	0.0190			0610.0	0.0190			0610.0	0610.0		
a	After	25	-			25	l			25	-		
Hole Linish (RHR)	Alter	15				15	!			15	ı		
H	Before coldwork	30	-			30	1			30	-		
-	Atter	0.3735	0 3735			0.3735	0 3735			0 3735	0 3735		
Hote diameter (in	After coldwork	0 3635	0 3635	 		0.3635	0.36.5			0 3635	0 3635		
¥	Before coldwork	0 3540	0.3540			6.3540	0.3540			0 3540	0.3540		
i I	ð <u>e</u>	-	2	3	4	-	2	3	7	-	2	0	•1
Specimen	e c	55				53				54			

day i hole cracked

PHASEII - TASK 4 - APPLICATION AND PROCESS PARAMETERS

Ti 6Al-4V 1%D edge margin, open, C/W, 70 ksi

TEST_401 (T) SPECIMEN 623080 DATE 10/22/73

100 kip Vibraphore 4000 cprn Materials D. Reese 2 FATIGUE CONDITIONS Max test load (kip) Max net stress (ksi) Test laboratory Load ratio (R) Test frequency Test engineer Test machine - Ream, C.W. ream 0.375 PASTENER INSTALLATICT Nominal hole size (in.) HOLE PREPARATION Torque on Ibi Process Type 'n. AISI 9260 steel Fel Pro 300 Manifelt max diameter (in 1 0.045 0.019 0.010 Split Mandrel taper (in 1 in) COLDWORK PROCESS Steeve thickness in I Sc. me Oranitation Interference (10.) Mandrel malmist Tule se thinn Sieeve TyDe Ti-6Al 4V (anneafed) Shot peen 3 50 x 2 Fig. 7A 0.250 3 125 0.562 SPEC:MENIDESCRIPTION (CI) burneds sign Marge & gage fen i Surface regarded E 10- margin tin ! Configuration Width in ! Material

Origin of failure (a)	and remarks									}			
Cycles	tailure	46.000]	-	90,000 C/W			-	68,000 C.W]	
Saye bar)	F.												
Fastener size fin)	Отатрыч												
Caidwork expension (iii)	Retained	\$600.0	0.0095	0.0095	0.0035	0.0095	0 0095	0.0095	0.0095	0 0005	0 0005	0.0095	0 0095
Cours expense	Actual	0.0180	00180	0.0180	08:00	08100	08100	0.0180	0.0180	08100	0.0180	0.0180	0.0180
	Atter	40	i	35	;	40		35		35	'	Ę	
HOW LOST (HHR)	After	15	i	15	-	15	1	15		15		51	
¥	Bofori Olden k	٩	!	25	:	30	_	25	:	35	,	30	
) -	Trees.	03/45	03745	0.3745	0 3745	0 3745	0.3745	0.3745	0.3745	03745	03745	0.3745	0.3/45
The partition of I	Attor Ch. SWOOD	0.36 %	n 3645	7.36,45	0.3645	0.3645	0 3045	0.3545	0.3645	0.3645	0.3645	0.3545	0.3645
Ī	u foru	0.35.0		-		`	İ	ł .	0.3550	1550	7	T	1
 -	<u> </u>	1	Ci	(7	"7	-	2	7	7		[• 	! ! • !
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	46				, a			-	1		[<u> </u>

APPLICATION AND PROCESS PARAMETERS PHASEII -TASK 4-

Ti-6AI-4V, 2-D edge margin, open, C/W, 70 ksi

DATE 10/19/73 SPECIMEN 623080 TEST_402 (T)

FATIGUE CONDITIONS Max hist load (kip) Maxinet stress (ks.) Test laboratory Load ratio (R) Test frequency Test engineer Test machine Ream, C/W, ream 0.375 FASTENER INSTALLATION Naminal bale size tin 1 MOLE PREPARATION Process Type Ē AISI 9260 steel 0.353 0.010 0.045 0.019 Split Mandret max diameter (m.) Mandrel taper (in in) Sleeve this kness (in) COLUWORK PROCESS Sieeve or entation Interference (ip.) Manufurl material Sleeve type Ti (SAI-4V (annealed) 350×2.00 Shot peen 0 520 0.750 3.50 SPECIMEN DESCRIPTION HOLE SOUTH (I.D.) Material garring Engermengin coll Surface treatment

Configuration

Width tun 3 Meterial

100-kip Vibraphore

Torque 'n Ib)

Fel Pro 300

Lubric 11.011

4000 cpm Materials D. Reese

Origin of failure	and remarks	C.W.				C/W				C.*		3	
Cycles	failure	49,000				56.000				52,000	-	-	
Fastener size for l	ŭ.										; ; 	-	
Fastened	Digitalisted												
Coldwork expansion (m.)	Retained	0.0085	0.0085	0.0085	0 0085	0.0000	06000	0 0000	0.0000	0.0095	0.0095	0.0095	0.0095
Cold	Actual	0.0180	0.0180	0.0180	0.0180	0.0180	0 0 1 8 0	0.0180	0.0185	0 0 185	0.0185	0.0185	0.0185
÷	Alter	35		35	-	25	,	20	!	75	,	<u>۾</u>	
Hore Linish (RMR)	After	15	-	15		15		15		12	-	5-	
Ĭ	Buture	35	_	30		30	1	35	:	30		25	!
_	Ather	0.3745	03745	0 3745	0 3745	0 3745	0.3745	0.3745	03745	0.3745	03745	03/45	0.3745
Hote diameter (in)	Atter Collegenth	0 3645	0 3645	0 3645	0 3645	0.3640	0.3640	0.3640	0.3640	0.3640	0.3640	0.3640	0 3640
Î	e efore:	0.3550	0.3550	0.3550	0.3550	0.3550		i "	0 3550	0.3545	0.3545	0 3545	U 3545
	ic	-	۲,	l ~	••	 - 	· .		-7	-	^	3	-7
	fig.	8				Ş				:6			

PHASE II - TASK 4 - APPLICATION AND PROCESS PARAMETERS

Ti-GAI-4V, 2%-D edge margin, open, C/W 70 ksi

TEST 4D3 (T) SPECIMEN 623080 DATE 10/22/73

5 (ks) 70	R) 01	!!!	2	
FATIGUE CONDITIONS Max net stress (ks.)	Load ratio (R)	Test trequency	Test engineer	
HOLE PREPARATION Nominal hole size (in.). Dozer CAN ream	Process	FASTENER INSTALLATION	Type.	Torque (in. lb)
COLDWORK PROCESS Interference (in.)	Sleeve type Sleeve thickness (in.)	Sleeve or entation. O AISI 9260 steel	Mandrel taper (in./in.)	Mandrel max diameter (in) C.333
SPECIMEN DESCRIPTION Fig. 7C Configuration	Material Ti-6Al-4V (annealed) Width (in)	Hale spacing (in.) 3.50 x 2.00 Edge margin (in.) 0.937	Material gage fin 1	Surface treatment. Shot peen

Origin of failure	and remarks	-	→ 33	00			CVM	00		-	CW			
Cycles	ţ,	failure	000'29				63,000				62.000			
Fastener size (in.)		Fit												
Fastener		Diameter												
Coldwork expansion (in.)		Retained	0.0095	0.0095	0600.0	0.0000	0.0095	0600.0	0.0095	0.0000	0.0000	0.0090	0.0095	ი600:0
Cold		Actual	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180
=		After	40	-	35	1	40	,	30	,	40	1	40	1
Hole finish (RHR)		After coldwork	15	1	15	1	15	1	10	1	15	!	15	:
9 1		Before	30	-	35	-	30	1	25	i	30	1	30	1
	1	After	0.3745	0.3745	0.3745	0.3745	0.3745	0.3745	0.3745	0.3745	0 3745	0.3745	0.3745	0 3745
Hole diameter (in.)		After	0.3645	0.3645	0.3640	0.3640	0.3645	0 3640	0 3645	0.3640	0.3640	0.3645	0.36.5	0.3640
HOH		Before	0.3550	0.3550	0.3550	0.3550	0.3550	0 3550	0 3550	0 3550	0.3550	03550	0 3550	0.3550
	107	ę	-	2	3	ব	-	2	3	-7	-	2	6	4
	Specimen	dash or	93	3			94				35			

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Ti-GAI-4V. 2%:D edge margin. open, C.W.

	53	70	41.5	0.1	4000 cpm	Materials	D. Reese	100-kip Vibraphore	
70 ksi	FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Test frequency	Text laboratory	Test engineer	Test machine	
(23/23		0.375	Ream, C.W. ream			٧C			
SPECIMEN 623080 DATE 19/23/73	HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	Fit	Torque (m. 15)
TEST_404[T] SPECIMEN		0.019	Split	0.010	AISI 9260 steel	0.045	0.045	0.353	Fel Pro 300
TEST	COLDWORK PROCESS	Interference (in.)	Sleeve type	Steeve thickness (in)	Sieeve orientation	Mandrel inaterial	Mandrel tapes (in (in)	Mandrel max diameter (in). 0.353	Lubricition
	SPECIMEN DESCRIPTION	Configuration Fig. 7D	Marman T. 6Al-4V (unnealed)	Width (19.1) 2.995	Hair 1786 (in.) al. 125 x 1 50	Edge margin for 3	Material gage for 1	Surface treatment Shot peen	

100	I	1	Hole hameter (m.)		Í	Hole Linish (RHR)	≈	Supplemental	Coldwork expansion (in)	Fastener	Fastener size (in.)	Cycles	7
	9 —	Batore rollby #6	After	Afler	Bufare	After	After	Actual	Retained	Culmeter	i i	failure	Origin Urrailure and remarks
16	-	0.3545	0.3540	0.3745	40	20	40	0.0185	\$600 0			90,000	→
	2	0:545	0.3640	0.3745	-	í	ſ	0.0185	ი თმ5				C/W.
		0.3545	0.3640	03745	35	15	35	0.0185	0.0095				
	-3	0.3545	0 3640	0.3745	:	-	1	0.0185	0.0095				
38	_	0.3545	0.3649	03750	30	15	35	0.0185	0.0095			81,000	
1	2	0.3545	0.3640	0.3750		-	,	0.0185	0.0095				M.
}		0.3545	0.3640	0.3750	35	15	40	0.0185	0.0095				
		0.4545	0.3640	03750				0 0185	0.0095				
٤	-	0.3545	0.3640	03750	35	15	30	0 0 185	5600 0			74.000	-
	2	0.3545	0.3640	0.3750			;	0.0185	0.0095				CW
	3	0.3545	0.3640	103750	35	15	35	0.0185	0.0095				
		0.3545	0 3640	0 37	'		i	0 0 1 8 5	0.0095			 	

*98 has 1 125 x 3 50 spacing

APPLICATION AND PROCESS PARAMETERS PHASE II -TASK4 -__

2%-D edge margin, open, C/W, 70 ksi T-6A1-4V,

> SPECIMEN 623080 DATE 10/22/73 TEST_405 (T)

FATIGUE CONDITIONS Max Irst load (kip) Max net stress (ksi) Test lationatory Load ratio (R) Test frequency Test machine Lest enginees Ream, C/W, ream 0.375 FASTENER INSTALLATION Nominal note see to ! HOLF PREPARATION Process Type = AISI 9260 steel 0.010 0.045 Mandret max diameter (in) 0.353 0.019 Sel Mandrel taper (in lin l Steeve thickness (in 1 COLDWORK PROCESS Sieeve or ientation Interference (in.) Mandrel material Sieeve type T: 6Al.4V (annealed)

1.50 x 3 50

Hole specing (in.)

3.375

With tin Marris

F.9. 7E

Configuration

SPECIMEN DESCRIPTION

0 9375

0.250

Material gade (in.) Eige margin lin 3

100 kip Vibraphore

Torque (in itil

Fel Pro 300

Lubrication

Shot peen

Surface treatment

D. Reese Materials

4000 cpm

41.5

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	arlore Arts	.		()	(Þ				{	}	(-			}	
	Origin of failure				- 100						-	· ·			-	1			₹
	\$ 5 c	tanore		00000	29.000				-			104,000	-	 - -	_			000	
E activities of the left 1			<u>.</u>				-							- - +		+			1
Part of the Part			():ameter				-							-				-	-
Coldwork	(mil nost educ		Retained		0.0100		0 0000	0000	0000	00000		0.0085		56000	3000	canno +	0.0095		0 0095
DI OC	At Belie		Actual		0.0186		08100		40 0 0 1 80	00100	00100	0.0185		0.0185		0.0185	0.0185		40 0 0185
			After		,	5 - -	1		40	_		,	3		1	38			40
	Hole finish (RHR)		After	- COMMINION	į	2	ı		15				01	:	-	15			
	£		Betore	coldwork		8			30				25			30		-	
			Alter	1.00		0 3745		C 7 / 5 / 0 /	0.2746.	1	0.3745		0.3745		0.3/40	0.3745		03745	
	(co., Japanierio alcon		After	COL: MOCH		0.3545		0 3640 (0 3/45		0.3550 10.3540	0.36.45	200	0.3640		0 35.19 0 3640	0.26.40	0 3040	0.3640	
) 		B.+Otr	COMPLET		0.35.65	, , , ,			0 3550		03550	n 35.45 0.3640		0.35.15	! ! ? ! : -	10,5545	10.3545	
			ž ?			-		r. _	 	•	١. ــــــــــــــــــــــــــــــــــــ	- I	_	-	٠.	-	,		!!!
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APPLICATION AND PROCESS PARAMETERS	
APPLI	
-TASK 4-	
PHASEII	

	TIONS	lks:1 70	kip) 12	0.1	600 cpm	Materials	D. Reese	60. to 80 kip	Hiene Los
	FATIGUE CONDITIONS	Max net stress (ks.)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
118/73		0.250	Ream, C/W, ream			NO	Hi-Lok, prot hd	Net to 0.0005 clearance	80
SPECIMEN 623080 DATE 11/18/73	HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	F.r (in.) Net 1	Torque (in ib)
,		0.14/0.15	Split	0.008	00	H.11 steel	0.015	0.230	Fel Pro 300
TEST. 4E1	COLDWORK PROCESS	interference (ID.)	Sleeve type	Sleeve thickness (in I	Steeve oftentation	Mandrel material	Mandrel taper (in /in]	Mandrel max diameter (in) 0.230	Lubrication
	7.0.F	9 de 1	Ti-6AI-4V	1.00	1.00	0.50	0.250	Shot peen	
	SPECIMEN DESCRIPTION	Configuration	Material	Width (in)	Hole spacing (in.)	E Jge margen lin)	Material gage fin !	Surface treatment	

Origin of fasture	and remarks				Failed at third hole from end		HO HO		Failed at center hole				Failed at fifth hole from end
Cycles	to failure	124,950	_			122,210				60,780			
Fastener size (in)	Fit	Net	Net	Net	Net	0.0005	0 0000	0 0005	0.0005	0 0005	0.0005	0.0005	0.0005
Fastenei	Diameter	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485	0.2485
Coldwork expansion (in l	Retained	0.0060	09000	0.000.0	0.0060	0.0060	0900.0	0900.0	0.0060	0.0060	09000	0.0000	0.0060
Col	Actual	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145
æ	Atter	20	1	25	ı	50	!	25	ì	 	:	20	_
Hole finish (RHR)	After coldwork	15	1	10	1.	10		10	I	i	01	-	15
Ť	Before coldwork	25	ı	25	_	20	1	25	ι	I	20	1	25
	Afree	0.2435	0 2485	0.2485	0 2485	0.2490	0.2490	0.2490	0 2490	0 2490	0 2490	0 2490	n 2490
Hole (fameter (in.)	After	0.2375	0.2375	0 2375	0 2375	0.2375	0 2375	0.2375	0.2375	0.2375	0 2375	r 2375	0 2375
Î	Before	0 2315	0.2315	0.2315	0 2315	0 2315	0.2315	02315	0 2315	0 2315	0.7315	0.7315	02315
3	ş	-	2	3	4	-	2	3	4	1	2	3	4
Specimen H		-				2				ĵ.			

AMETERS
AND FROCESS PAF
PPLICATION AN
-TASK 4- A
PHASE IL

15-hole, dual, C/W, prot hd Hi-Lok, 70 ksi

Ti 6A) 4V,

7

<u>11/73</u>	6	0.250	Ream, C/W, ream		
SPECIMEN 620380 DATE 11/21/73	HOLE PREPARATION	Nominal hole size (in.)	Process		
i		0.014/0.015	Split	0.008	000
TEST_4F1	COLDWORK PROCESS	Interference (in.)	Sieeve type	Sleeve thickness In)	Spece Orientation

60. to 80-kip Riehle-Los

Materials D. Reese

Test laboratory

Test engineer. Test machice

Hi Lok, prot hd

FASTENER INSTALLATION

H.II steel

Sigeve or entation

Ti-6AI-4V (annealed)

SPECIMEN DESCRIPTION

Configuration

Material

Width Lin Skin, 2 50, stringer, 1.0

Edge margen (in 1 Skin, 1.25, stringer, 0.50

8

Hole specing

0.015

Mandrel taper (in /in)

잃

Torque for (b)

Fel Pro 300

Lubric stron

Mandrel max diameter (in) 0.2305

0.250 Shot peen

> Material gage fin E Surface treatment

Type F.tf(in.)

md: 009

Load ratio IRI Test frequency

51.8

FATIGUE CONDITIONS
Max net stress (ks.)
Max test toad (k.p)

	Organ of failure			-	CW)		Failed at minth fastener			C/W W			}	Failed at ninth fastener			C/W Ha	
	Cycles	farlure		40 190							39,840							47,330		
01107			٤	1014	12 12	Net		Set	1017	120	Net		Net	 -	Nei	; 	Net	Ž	1 1 1	Se :
Cal avia sometre	186		Olameter	1000	0.2495	0 2495		01 2495	0.0405	0.7495	0.2495	0.2733	0.2495		0 2495		0.2495	7000		0.2495
Coldwork	expansion (in)		Retained		0.0070	0,000		0.0070		0.0000	0,000	2/20	0,000	200	0.000		0.0000	0.003	0/000	0.000
S	expans		Actual		0.014	6100	7100	0.014		0.014		0.014	,,,	200	0.014		0.014		0014	0.014
	_		After		20			20		:		20			۶	3	ı		2	
	Hole traish (RMR)		After coldwork		15			31	-	,		15		-	,	0		1	15	i i
	¥		Britare		25		1	20				25				75			25	 - -
		+	Alter		0.2405		0.2495		0.7495	3000	1 (48)	0.2495		0.2495		0 2495		0 7495	0.2495	1
	Hole d'ameter (in.)		A fear		30206	0.533	0 2395		0 2395		0 2395	2000	0.6330	0.2395		0 2395		0 2395	0.2295	2557. 1 6567.0
	ī		Ветоге	COIOMOGE		0.2375	102225		0 1325	•	0 2325	7000	0.7375	3000	-5555+	0 2325 0 2395		0 7375 0 2395	אנגני ט	
1			ş		 -	-] _]	7	-	٠,	1			-	7	-	~ 	1	- 7	-	
		Specimen	de oc			4											 - -	_		-

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ADDITION AND PROCESS PARAMETERS	
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A 210 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	ASK 4 -

		0/	50.5	1.0	and china	Widter Idea	D. Heese	60 to 80 kip	
70 ksi	FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
SPECIMEN 62308G DATE 11/21/73		Nominal hale size in 1	Process Ream, C/W			FASTENER INSTALLATION	Type Hi Lok, prot hd	Fig (in.) Net to 0.0005 clearance	Tor sue (in ib)
TEST_4F2SPECIMEN_6	Ŧ	0.014.0.015	Split	0.008	0,	H-II steel	0.015	(in) 0.242	Fel Pro 300
7ES	COLDWORK PHOCESS	Literlerence (In.)	Steeve 1yDe	Steeve thickness (in)	Sleeve orieniation	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter (in)	Lubricition
	SPECIMEN DESCRIPTION	Configuration Fig. 8	Material Tr-6Al-4V (sinnealed)	Width In Skin, 2.50, stringer, 1.00	Hole specing	Edge margin (in.) Skin, 1.25, stringer, 0.50	Material gage fin) 0.250	Surface treatment Shot peen	

Origin of failure	and remarks	Fajled at eighth fastener stringer	7 0 7 1		Failed at ninth fastener-skin	HO			Failed at eighth fastener	H T			Failed at ninth fastener
Cycles	failure	98,040				187,150				191,330			
Size (in)	Fit	0.0005	0 0000	0.0005	0.0005	0.0005	0.0005	0.0005	3 0005	0.0005	50000	0 0000	0.0005
Fastener size fin	Diameter	0.2495	0.2495	0.2495	0 2495	0.2495	0.2495	0.2495	0.2495	0 2495	0 2495	0.2495	0.2495
Coldwork expansion (in)	Setained	0.0070	0.00.0	0.00.0	0.00.0	0.0070	0.0070	0.0070	0.0070	0.0000	0.0070	0.0070	0.000
Cold	Actual	0 0 1 80	0.0180	08100	0 0 1 8 0	0.0180	00180	0.0180	0.0180	0 0 1 8 0	0.0180	0.0180	0.0150
	Atler							Ì		 	 		
Hofe Sinish (RHR)	Alter	٥١	01	15	15	10		10		01	, ,	ي 0	
9	Betore	20	20	7.5	CS.	20		20	1	20		92	
_	After											1	
Hale d'ameter (m	After	0.2500	0.2500	0 2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	0 2500	0.2530
Į Ū	Before	0 2430	0 2430			0 2430	0 2430	0.2430	0.2430]		0.00	1
	30 %	-	7	3	4	-	62		-	-	2	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	-
	de de de de de de de de de de de de de d					a	,			o			

4V. 4.1851. Jual. Hi-Lok.	(kv) 48–2024 T851 (kv) 44.3 (kvp) 0.1 0.1 0.1 Materials V D. Reese 60 to 80-kip Riehle-Los	
Skin, Ti 6Al-4V. Stringer, 2024-T851, 15-hote, dual, C/W, prot hd, Hi-Lok.	FATIGUE CONDITIONS Max test load (ksp) Load ratio (R) Test frequency Test laboratory Test machine	
APPLICATION AND PROCESS PARAMETERS 3 SPECIMEN 623080 DATE 11/12/73	FASTENER INSTALLATION HOLE PREPARATION FRAME CAN, ream Process Ream, CAN, ream Process Ream, CAN, ream Process Ream, CAN, ream Process Ream, CAN, ream Ream, CAN, ream Notes in CAN, ream Ream, CAN, ream Ream, CAN, ream Ream, CAN, ream Fraction in the control of	
PHASE II -TASK 4 - APPLICATION AN	00.0055 (Ju.) Split Split Split 10.008 attor 11.11 steel 11.12 10.015 attor 12.005 attor 13.0015 attor 14.11 steel 15.12 10.015 attor 16.12 10	Control of the Contro
Ħ	SPECIMENTESCRIPTION Fig. 8 Configuration Skin, Ti-6At 4Viannealed) Material Skin/16At 4Viannealed) Material Skin, 2.50 stringer, 1.0 Note spacing Skin, 2.50 stringer, 1.0 Skin, 1.25, stringer 0.50 Material gege tin 1 Skin, 1.25, stringer 0.50 Material gege tin 1 Skin, 1.25, stringer 0.50 Southair treatment Shot peen	

	Origin of failure and remarks							stenei						istener - stringer				5 -	7	fastenerskin	
	Origin of		- -					Failed at eighth fastener	-		CA			Failed at twefth fastener - stringer			*S			Failed at eleventh fastenerskin	İ
	ر دون د	lailure		61,590						79,170		-			-	64,620		-	: : :		
(00) 078		ï		Net		Ner	Net	1		Zez	Ž	+	Se:	\ \ \	Z	Net		1 2 1 1	Ž	جُ	
(ur) d/ss sacratic 3		Diameter		0.2495		0 2495	0.2495	2017	0.2495	0 2495	90,00	0.2495	0.2455		0.2495	0.2495		0.2495	0.2495	╀	
Coldwork	expansion fin l	Retained		0.0075	2	0.0075	1 200	2000	0.0075	0.0075		0.0075	37.00.0		0 00075	3,000	300	0.0075	0.0075	0.0075	,
Cold	suedx a	Actual		***	100	0.014		0.014	0.014		7.0.0	0.014		0.014	0.014		0.014	0.014	4100	2 0	,
	~	Atter	rear	}	2	1		2	,	!	2	_	-	2	i	+	2	_	1 6	-	-
	Hole fraish (RHR)	Ativ	Cottawork		15		1	15		.	15			5.			15				
	HO	1	COLUMBER		25			25			25			25			25	! : !	-	22	
			Atter ream	+	0.2495	 -	0.2495	0.2495		0.2475	0.2495		0 7495	0.2495		0.2495	0.2495		0.24/15	0.2495	0.2495
	(n) separation (n)		Atter	ı	0.2400	1	C 240C			0.2404)	0.2400		0 1400	17076		0.2400	0.0400		0.2400	001.00	10.2400
	Hali		Betor	a forest indi	0 2325	1	0.2325	1	1	0 2325	0.2325	4-1-1-1-1	0.2325		1-678770	0.2325	•	0.52.0	10.2325	16.2325	10.00
		 5 1	ş		-	-	2	-	.	.,	 		~	-	<u> </u>	-•	 -	 - -	r.		; -
		Sperimen	<u> </u>	_		2			!						i i			- 22		: : 	+-

APPLICATION AND PROCESS PARAMETERS
PHASEII -TASK4 -

TEST_4G1 SPECIMEN_623080 DATE 10/9/73

Ti-6AI-4V,
high load transfer,
CAW, net fit Hi-Lok,
0.010 micarta.
40 ksi

70 37	0.1 600 cpm	Materials D. Reese	60- to 80-kip Riehle-1.os	
FATIGUE CONDITIONS Max net stress (ksil	Load ratio (R)	Test laboratory	Test machine	
0.375		- NOI	Net to 0.0005 clearance 240	
HOLE PREPARATION Nominal hole size (in)	Process	FASTENER INSTALLATION	Type Fit (in.) Torque (in.lb)	
610.0	Split 0.010	0° AISI 9260 steel	0.045 0.353 Fel Pro 300	
COLDWORK PROCESS	Sleeve type Sleeve thickness fin ?	Sleeve or initiation Mandret inalieral	Mandret taper fin 'in) 0.045 Mandret max diameter (in) 0.353 Eel Pro	
PTION Fig. 10	Ti-SAI-4V (annealed)	0.75	0.250	
SPECIMEN DESCRIPTION F Configuration	Material Width (in)	Hale spacing(10.) 1,50 Edge margin (in.) 0.75	Material gage fin 1 Surface treatment	

	Origin of failure	and remarks	7	C,W Hd				4	H					4	THE STATE OF THE S	17			
	Cycles 5	2		21,280					22,500	_				1 2 5	17,340				
	3,64	ī		Net	Net	1 12	1	ž	Ž	S		Nei	Net		Net	Zer	Zet	Z	
0.000	rastenci	Ом петег		0 3740	0 3740		03/40	6.3740	03740	(1870.0	2	0.3740	0.3740	St. Co.	0 3740	03740	0.3740	03/40	
Coldwork	1 t, ub	Retained		0600.0	06000		0.00.0	06000	06000	900	O DOO	0.0000	0.00	0.0030	06000	0.000	06000	0000	2000
Cold	expansion, 1	Actual		0.0185	0.0185		0.0185	0.0185	0 0 185		00185	0.0185	1	0.0185	0.0185	0.0185	0.0185		0.0163
		Atter	Fear	55			09	;	98						20	 	7		_
	Hole finish (RHR)	After	coldwork	20				;	8						8		-	. !	
	î	Before	COLOMOTIK	45		,		1	dr.	?	1	09		•	20		\ 	-	
		1	r.ear	0 2740	2	0.3740	0.3740	0.3740	0 2 2 40	0.3/40	0.3740	0.3740		0.3740	0.3740	27.60	0.57	0.3740	0 3740
	Hole dameter (in)		coldwork	2030	0.3033	0.3635	0.3635	0.3635	2000	0.3535	9.3635	0.3635	555	0.3635	0.3635	6000	0.3635	0.3635	0.3635
	Ī		Before	30.00	0.3545	0.3545	0 3545	Т	Ţ	0 3545	0.3545	0.36.46	0.3343	0 3545	0.3E.AE.	0.3343	0.3545	C.3545	0.3545
		ė s	?	-	-	2	3	,		-	2	,	٠]	٠	-	, ,	,	m	4
		Sperimen	2		-					۸.					,	m			

Ti 6AI-4V. high load transfer. C.M. 0.002 clearance Hi-Lok.	0.010 micarta, 70 ksi	FATIGUE CONDITIONS	Max net stress (ks.) 70	N. ream Max test load (ktp) 36.3	Load ratio (R) 0.1	Test frequency 600 cpm	Test lahoratory Materials	rot hd Test engineer D. Reese	arance Test nine 60 to 80 kip	
PHASE !! -TASK 4 - APPLICATION AND PROCESS PARAMETERS	G2 SPECIMEN 623080 DATE 10/9/73	HOLE PREPARATION	0.019-0.020 Nominal hole size (in) 0.375	Split Process	0.010	00	AISI 9260 steel FASTENER INSTALLATION	0.045 Type Hr Lok, prot hd	0.353 Fr (in.) 0.001.0.002-in, clearance	Fel Pro 300 Torque (in lb) 240
PHASE II -TASK 4 -	16.57 462	COLDWORK PROCESS	Interference (ID.)	Steeve type	Steeve thickness (in)	Sleeve orientation	Mandrel material	Mandrel tape: (in /in)	Mandrel max diameter (in)	Lubricition
		SPECIMEN DESCRIPTION	Configuration Fig. 10	Material Ti-6Al-4V (annealed)	3.00 Width (in)	Hole spacing (in.) 1.50	Edge margin (in)	Material gage (in.) 0.250	Surface treatment Shot peen	

Orgn of failure	and remarks	F	4			- NO 3	3			C/W Hd	- J		
Cycles	failure	18,660				20,640				20,000			
Fastener size im l	آء د	0.002	0.002	0.002	0.002	0 002	0.002	0.002	0.002	0.002	0.002	0 002	0 002
Fastene	Diameter	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740
Coldwork expansion tin)	Retained	0600.0	06000	0600.0	0600.0	0.0000	0600.0	0600.0	06000	06000	06000	06000	0.0000
Noo expans	Actual	0.0185	0.0185	0.0185	0.0158	0.0185	0.0185	0.0185	0.0185	0.0185	7,0185	0.0185	0.0185
æ	After	09	·		65	09	_	65	-	20		i 	1
Hole (inish (RHR)	After	25	:	1	l	20	 - -	!	'	2	1		
Ť	Before	65	•	70	1	90	1	65	:	55	-		
	After	0.3760	0.3760	03760	0.3760	0.3760	0.3760	0.3760	0.3760	0.3760	0.3760	0.3760	0.3760
Hole diameter (m.)	After	0.3635	0.3635	0.3635	0.3635	0.3630	0.3630	0.3630	0.3630	0.3635	0.3635	0.3635	0.3635
î	Before coldwork	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545		0.3545
	Hole or	_	2	٣	4	-	2	۳	4	-	2	 m 	4
90	de de de	4				ċ				Ģ			

PPLICATION AND PROCESS PARAMETERS
PHASE II -TASK 4 -

	PHASE II -TASK 4 -	APPLICATION,	PHASE II - TASK 4 APPLICATION AND PROCESS PARAMETERS	METERS	T)-6A1-4V.	
	TEST4G3		SPECIMEN 623080 DATE 10/10/73		high load transfer, C/W, 0.002 interference Hi. Lok, 0.010 micarta, 70 ksi	Hi-Lok.
PECIMEN DESCRIPTION	COLDWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS	.0
Configuration Fig. 10	Interference (in.)	0.019.0.020	Nominal hole size (in.)	0.375	Max net stress (ks.)	70
Material Ti-SAI-4V (annealed)	Sleeve type	Split	Process	Ream C/W, ream	Max test load (kip) 37.5	37.5
Width (in) 3.00	Sleeve thickness (in)	0.010			Load ratio (R)	0.1
Hole spacing (in.) 1.50	Sleeve orientation	00			Test frequency	600 cpm
Edge margin (in) 0.75	Mandrel material	AISI 9260 steel	FASTENER INSTALLATION	2	Test laboratory	Materials
Material gage (in)	Mandiel taper (in /in.)	0.045	Туре	Hi Lok, prot hd	Test engineer	D. Reese
Surface treatment Shot peen	Mandrel max diameter in) 0.353	0.353	Fit (in.) 0.001-0.0	0.001-0.002 interference	Test machine	60. to 80.kip
	Lubrication	Fel Pro 300	Torque (in Ib)	240.250		Riehle-Los

Oron of failure	and remarks		Hd CyW		}	-	Hq C/W		}	-	Ho I I I I I I I I I I I I I I I I I I I	<u>-</u>	}
Cycles	to failure	24,140				24,700				26,630			
Fastener size (in)	Fit	0.00	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fastene	Diameter	0.3740	0.3740	0.3740	0.3740	0.3740	0 3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740
Coldwork expension (in)	Retained	0500.0	06000	0:00:0	0.0000	0.0085	2800.0	06000	0 3030	5.0085	0.0085	0.0085	0600.0
Col	Actual	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0185	0.0180	0.0180	0.0180	0.0185
~	Atter	20	i	I	I	20	ı	1	1	20		1	i
Hale finish (RHR)	After coldwork	20	i !	- 1	1	20		1	1	20	-	I ;	!
ĭ	Before coldwork	09	_	_	_	60		ı		70	_	I	
-	After	0.3730	0.3730	0.3730	0.3730	0.3730	0.3730	0.3730	0.3730	0.3730	0.3730	0.3730	0.3730
Hole diameter (in l	After coldwork	0.3635	0.3675	0.3635	0.3635	0 3630	0.3630	0.3635	0.3635	0.3635	0.3630	0.3630	0:3630
ĭ	Before co rtwork	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3545	0.3550	0 3550	0.3550	0.3545
ĕ	O _t	-	2	3	7	-	2	3	4	-	2	3	4
Specimen	26 00	7.				κĢ				ο̈́			

SPECIMEN 623080 DATE 10/30/73	
	TEST 464 SPECIMEN 623080 DATE 10/30

	Origin of failure	and remarks		•				-)
	Cycles	2	fature	000				
	Fastener size lin)		Ī		0.0005	. 2005	0.0005	
	Fastener		Diameter		20 0.0180 0.0095 0.3735 0.0005 11,580		0.0180 0.0095 0.3735 0.0005	
	expansion (in)		Retained Diameter		0.0095		0.0095	1
	exped xa		Actual		0.0180		0.0180	
	=		After		70		i	
	Hole finish (RHR)		After		15		١	
	Ĭ		Before After coldwork		25	1	:	
			After		0.3740		03340	
	Hole diameter (in)		Before After		26.00	0.3550 0.3043	0 3645 0 3740	מיים
	Ĭ		Before		0 0 0	0.3550	0 3550	ć
		1	ğ		-	-	2	
		Specimen	ou ou		9	01:		

60 to 80 kip Righle-Los

D. Reese Materials 600 cpm

Test laboratory

Test engineer Test machine

Hi.Lok (flush hd)

FASTENER INSTALLATION

AISI 9260 steel

Net to 0.0005 clearance 240.250

Torque (in. lb)

Fel Pro 300

Lubrication

Mandrel max diameter (in). 0.253

Shot peen

0.250

Material gage (in) Sustace treatment

Edge margin (in)

F.(10.)

Type

0.045

Mandrel taper (in 'in)

Load ratio (R) Test frequency

0.010

Sleeve thickness (iii) Steeve or entation Mandrel material

3.00 3.50 0.75

Width tin) Material

Hole spacing (in.)

SPECIMEN DESCRIPTION

Configuration

37.3 0.1

Orign of failure	and remarks	₩ H H			Failed at side plate	HA			Failed at side plate	C.W.			Failed at side plate
Cycles	fariure	11,580				6,200				11 170			
Fastener size (in)	F.	0.0005	0.0005	0.0005	0.0005	0 0010	0 000 0	0.0110	0 0005	0 0000	0.0005	0.0005	0.0005
Fastener	Diameter	0.3735	0.3735	0.3735	0.3735	0.3730	0.3730	0.3730	0.3735	0.3735	0.3735	0.3735	0.3735
work on (in)	Retained	0.0095	0.0095	0.0095	0.0095	0.0100	0.0105	0.0105	00100	0.0095	0.0100	0.0100	0.0095
Coldwork expansion (in)	Actual	0.0180	0.0180	0.0180	0.0180	0.0185	0.0185	0.0185	0.0185	0.0180	08100	0.0180	0.0180
 2	Atter	20	ļ	20	!	20	\ \ \	20	'	20	 	2	!
Hole finish (RHR)	After	15	1	15	1	15		15		15	:	15	;
9 H	Before	25	:	30		30		25		30		25	
	After	0.3740	0.3740	0 3740	0.3740	0.3740	0.3740	0 3740	0.3740	0.3740	0.3740	0.3740	0 2 2 40
Hole diameter (in)	After	0.3645	0.3645	0.3645	0.3645	0.3645	0.3650	0.3650	0.3645	0.3645	0.3650	0.3650	
19 H	Before	0.355.0	0.3550	+-	1	0.3546	T	1	0.3545	0.3543	2000	0.3330	2
	Hole	-	2	~	, 4	-	,	,	4	-	~	m	-
	Specimen dash no	-	2			:				:	71:		

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Ti-6AI-4V,
high load transfer,
C/W, net fit Hi-Lok,
No micarta

Configuration

SPECIMEN DESCRIPTION

Width fin) Material

COLDWORK PROCESS Interference (in.) 0.019 Steeve type	61 4	MOLE PREPARATION Nominal hole size (in.) Process	0.010	FATIGUE CONDITIONS Max net stress (ks.) Max test load (krp)	37.3
Sleeve thickness (iii) 0.010 Sleeve orientation 0° Mandrel material	0° 0° AISI 9260 steel	FASTENER INSTALLATION	<u>z</u>	Load ratio (R) Test frequency	600 cpm Materials
Mandiel taper (in /in.) 0.045	15	Type	Hi Lok, prot hd	Test engineer	D. Reese
Mandrel max diameter (in) 0.353	0.353 Fel Pro 300	F ₁₁ (in.) Torque (in.ib)	Net to <u>0.0005 clearance</u> 240.250	Test machine	60 to 80 kip Riehle Los

Material gage (in) Surface treatment

Edge margin (in)

Hole spacing (in.) 1.50

Contract of failure	and remarks		PH PH		}		C/W Hal				C/W		
Cycirs	to tarture	30,700				39,950				33,630	 		
Fastener size (in.)	ī.	0.0005	0.0005	0.0005	0.0005	0.0005	Net	Net	Net	0.0005	0.0005	0.0005	0.0005
Fastene	Diameter	0.3735	0.3735	0.3735	0.3735	0.3735	0.3740	0.3740	0.3735	0.3735	0.3735	0.3735	0.3735
Caldwork expansion (in)	Refained	0.0100	0.0100	0.0100	0.0100	0.0110	0.0095	0.0095	0.0095	0.0100	0.0100	0.0100	0.0100
Col	Actual	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	03.0180	0.0180	0.0180
æ	After	25	1	52	ì	25	ı	25	÷	25	1	52	_
Hale finish (RHR)	After	15		15	1	15	1	10	i	15	ı	10	-
¥	Before coldwork	20	!	25	1	25	-	30	ł	30	:	25	-
()	After	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740
Hole diameter (-n.)	Africoldwork	0.3650	0.3650	0.3650	0.3650	0.3650	0.3645	0.3645	0.3645	0.3650	0.3650	0.3650	0.3650
Ĭ	Before	0.3550	0.3550	0.3550	0.3550	0.3550	0.3550	0.3550	0.3550	0.3550	0.3550	0.3550	0.3550
HOH.	n0	ı	2	3	4	-	2	~	4	-	۲.	3	4
Specimen	ا ا	.13				.14				-15			

	PHASE 11 -TASK4	1	APPLICATION AND PROCESS PARAMETERS	ARAMETERS	Ti-6Al-4V,	
					C/W, net fit Hi-Lok,	
	TEST466	1	SPECIMEN 623080 DATE 11/1/73	11/1/73	upset removed, 70 ksi	
SFECIMEN DESCRIPTION	COLDWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS	
Configuration Fig. 10	Interference (in,)	0.019	Nominal hole size (in)	0.375	Max net stress (ksi)	70
Material Ti-6Al-4V (annealed)	Steeve type	Split	Process	Ream, C/W, ream	Max test (bad (kip)	37.3
Width (in) 3.00	Sleeve thickness (in.)	0.010			Load ratio (R)	0.1
Hole spaceing (in.) 1.50	Sleeve orientation.	00			Test frequency	то сом то
Edg. margin (in) 0.75	Mandrel material	AISI 9260 steel	FASTENER INSTALLATION	ATION	Test laboratory	Materials
Material gage (in) 0.250	Mandrel taper (in /in.)	0.045	Туре	Hi Lok prothd	Test engineer	D. Reese
Surface treatment. Shot peen	Mandrel max diameter (m.), 0.353	0.353	F.r (in.)	Net to 0.0005 clearance	Test machine	60. to 80 kip
	Lubrication	Fel Pro 300	Forque (in. lb)	240.250		Riehle-Los

Origin of failure	and remarks		C/W Hd				C/W				C/W H/W H/G		
Cycles	failure	98,140				36,180				31,890			
Fastener size tin)	Fif	Net	Net	Net	Net	Net	Net	Net	Net	ívet	Ner	Net	Net
Fastener	Diameter	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0 3740	0.3740
Caldwork expension (in)	Retained	0.0950	0.0950	0.0350	0.0950	0.0950	0.0950	0.0950	0.0950	05600	0.0950	0.0950	0.0950
Solt expens	Actual	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	08100	0.0180	0.0180
IJ	After	20	_	20	'	20	1	20	-	20	, 1	20	'
Hole finish (RHR)	After caldwork	15		15	:	15	1	15		15	1	15	
H _e	Before	25	1	25	!	25	_	20	ı	30	!	25	_
•	Afrer	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0 3740
Hole (bameter (m.)	After coldwork	0.3645	0.3645	0.3645	0.3645	0.3645	0.3645	0.3645	0.3645	Ì	0.3650	0.3650	0.3650
7Hc	Sefore coldwork	0.3550	03580	0:3550	0.3550	0358.0	0350	0.3550	03280	0.3550	03550	0.3550	0.3550
ajo H	Ou Ou	-	2	3	4	1	2	3	4	-	2	3	4
Specimen	<u>နို</u> င်	-16				71.				18			

4- APPLICATION
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TEST.	TEST_467 SPECIMEN.	SPECIMEN 623080 DATE 11/1/73)
COLDWORK PROCESS		HOLE PREPARATION		FATIGU
Interference		Nominal hole size (in) 0.375	2	X.
Sleeve type		Process	ε	Š
Steeve thickness lin)				LOBE
Sleeve orientation				ב

> *	carta,	IONS	70	ipl 37	0.1	600 cpm	Materials	D. Reese	Materials	Highle Los
Ti-6Al-4V.	0.010 in. micarta, 70 ksi	FATIGUE CONDITIONS	Maxiner stress (ksi)	Max test load (kip)	Loadratio (R)	Test frequency	Test laboratory	Test enqueer	Test machine	
ND PROCESS PARAMETERS	DATE 11/1/73	RATION	Nominal hole size (in) 0.375	Ream			ASTENER INSTALLATION	Taper lok, prothd	Boeing class F (0.187-0.289)	240.250
ND PROC	23080	OLE PREPARATION	Nominal h	Process			ASTENER	Type	F.ı (in.)	

240.250

Torque (in th)

Mandrel max diameter (in). Mandre: taper (in /in)

Surface treatment Shot peen

0.250

Hole spacing (in.) 1.50

Width (in) Material

Edge margin (in) Material gage (in.) Lubrication

Mandret material

Ti-6Al-4V (annealed)

Fig. 10

Configuration

SPECIMEN DESCRIPTION

FASTENER INSTALLATION

Origin of failure	and remarks	₽ H				-]		- II			
Cycles	to failure	73,970				78,990				62.280			
Fastener size (iii)	Fit	Class F	Class F	Class F	Class F	Class F	Class F	Class F	Class F	Class F	Class F	Class F	Class F
Fastenei	Diameter									į			
Confiwork enpansion (in.)	Retained												
Cons	Actual												
	After	20	1	25	١	24	1	8	20	20	,	20	,
Holy Linish (RHR)	After		ļ										
Î	Butore												
1.m.)	After	0.2800	0.2800	0.2800	0.2800	0.2800	0 2800	0.2800	0.2800	0.2800	0.2800	0.2800	0.2800
Fastener protrustion (in.)	After												
Fastent	Before cor twork												
	101	-	2	3	4	_	2	~	4	-	2	3	4
	Specimen	61.	2			۶	Ş			7	7		

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PHASE II -TASK 4 - APPLICATION AND PROCESS PARAMETERS TEST 4G8 SPECIMEN 623060 DATE 10/31/73 HOLE PREPARATION Interference Nominal hole size (in) 0.375 Steeve type Process Ream	Load ratio (A)	Max rest load (kip)	Max not stress (ksi) 7	FATIGUE CONDITIONS	70 ksi	Taper Lok, push hd, 0.010-in, micarta,	Ti-6AI-4V.
TASK 4 — APPLICATION AND PROCESS PAR TEST 4G8 SPECIMEN 623080 DATE 10/3 HOLE PREPARATION Nominal hole size (in) Process		Ream	0.375		1/73	AMETERS	AMETERS
TASK 4 - APPLICATION TEST 4GB SPECIMEN OCESS		Process	Nominal hole size (in)	HOLE PREPARATION	623060 DATE 10/3	AND PROCESS PAR	AND PROCESS PAR
TASK 4 TEST_					1	- APPLICATION	- APPLICATION
COLDWORK PRI	Steeve thickness (in.)	Steeve type	interence	COLDWORK PROCESS	TEST	PHASE II -TASK 4	PHASE II - TASK 4

60 to 80 kip	Rienle-Los	
Test machine		
f.t (in.) Boeing class F. (0,187.0,289)	Torque (in 15) 240.250	
Mandrel max diameter (in)	Lubrication	
een		

Materials D. Reese

Test laboratory Test frequency

Test engineer Test machine

Taper Lok flush hd

Type

FASTENER INSTALLATION

Siegve orientation Mandrel material

Ti-6A1-4V (annealed)

3.00 55 0.75

Width (in) Material

Hole spacing (in.)

Fig. 10

Configuration

SPEC:MEN DESCRIPTION

Mandret max diameter (in).. Mandrel taper In /in)

0.125 side plate 0.250 center

Material gage (in.)

Edge margin (in)

Shot peen

Surface treatment

600 cpm 0.1 37

a la la la la la la la la la la la la la	and remarks	\{ +-:	¥	7	}	-	- (-)	<u>-</u> کو	}		(
Original to cervice	ar Dree	-			Failed in side plate	•		+	Failed in side plate	•			Failed in side plate
Cycles	to failure	065'6				8,450				8,740			
Fastener size (in)	F 11	Class F	Class F	Class F		Class F	Class F	Class F	Class F	Class F	Class F	Class F	Cluss F
Fastene	Diameter												
Coldwork expansion (in)	Retained												
Cote	Actual												
â	After	20	1	25	-	20	-	30	1	25	-	20	1
Hole finish (RHR)	After coldwork												
I	Before coldwork												
(in.)	After	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
Fastener protrusion (in.)	After coldwork												
Fasten	Before coldwork												
ion	٤	-	2	3	4	-	2	3	4	,	2	3	4
Specimen	4 o	.22				23				.24			

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PHASE II -TASK 4 - APPLICATION AND PROCESS PARAMETERS

riedal-4V. ream only, net fit, Hi-0.010-in, micerta

	TEST_4G9 SPEC	SPECIMEN 623080 DATE 10/10/73	70 ksi	
SPECIMEN DESCRIPTION	COLDWORK PHOCESS	MOLE PREPARATION	FATIGUE CONDITIONS	
Confirm-ration Fig. 10	Interference	Nominal hole size (in) 0.375	Max net stress (ks.) 70	
Material Ti-6Ai-4V (annealed)	Sieeve Iybe	Process Ream	Max test load (kip) 37	
Width (in) 3.00	Sleeve Thickness (in)	1	Load ratio (R) 0.1	
Hole spacing (in,) 1.50	Sleeve orientation	ı	Test frequency 600 c	600 cpm
Edge margin lin) 0.75	Mandrel material	FASTENER INSTALLATION	Test laboratory	Materials
Material gage fin 1	Mandret taper (in /in)	Type Hi-Lok, prot hd	Test engineer	D. Reese
Surface treatment Shot peen	Mandrel max diameter (in)	Fit (in.) Net to 0.001 clearance		60- to 80-kip
		Torone In Ba	Riehle-Los	.Los

1 10 0000	and remails				}	-	PH THE PHANE			4	¥		}
Cycles	factore	19,050				18,060				10,940			
Fastener size (i.n.)	F : f	0.001	100.0	0.001	100.0	100.0	0.001	0.001	0.001	0.001	0.001	100:0	0.001
f astener	D-ameter	0 3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740	0.3740
Coldwork expansion (in)	Retained												
suedxa	Actual												
₹	After	40	1	1	ı	i	05	_	_	_	40	_	_
Hole finish (RHR)	After												
Ĭ	Betore coldwork												
f:	After	0.3750	0.3750	0.3750	0.375.0	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750
Hole diameter (in.)	Alter												
H	Before coldwork												
Hole		-	2	3	4	-	2	3	4	-	2	3	4
Sperimen	oc C	.25				.26				.27			

										Oppose													
												Γ											
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							ل]? 	٦C		٦E											
E REAL	NGS A	WDCAL	CULATE	DSTRESS	ES-TIT	ANIOM	Ļ			Opposete sede													
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AGE SELON GAGE	2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	F READINGS A Read Read Read Read Read	READINGS AND CALC 0 60 135 12 126 213 911 1386 573 812 1786 580 1354 178 650 154 170 515 170 170 1718 672 170 1718 672 170 1718 672 170 1718 672 170 1718 672 170 1718 672 170	## FEADINGS AND CALCULATER 0 60 115 210	READINGS AND CALCULATED STRE	### FREADINGS AND CALCULATED STRESSES—TITE O 60 13.5 1.0 28.5 0 1.0 1.0 1.0 1.0 2.0 2.0 1.0 1.0 1.0 1.0 2.0 0 1.0 1.0 1.0 2.0 2.0 1.0 1.0 1.0 2.0 2.0 1.0 1.0 1.0 2.0 2.0 1.0 1.0 1.0 2.0 2.0 1.0 1.0 2.0 2.0 2.0 1.0 1.0 2.0 2.0 2.0 1.0 1.0 2.0 2.0 2.0 1.0 1.0 2.0 2.0 2.0 1.0 1.0 2.0 2.0 2.0 1.0 1.0 2.0 2.0 1.0 1.0 2.0 2.0 1.0 1.0 2.0 2.0 1.0 1.0 2.0 2.0 1.0 1.0 2.0 2.0 1.0 2.0 2.0 2.0 1.0 2.0 2.0 2.0 1.0 2.0 2.0 2.0 1.0 2.0 2.0 2.0 1.0 2.0 2.0 2.0 1.0 2.0 2.0 2.0 1.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0	SSES-TITANIUM 0 0 0 231 232 233 233 233 233 234 234 234 234 234	SSES-TITANIUM 0 0 0 6 272 233 296 -932 -1413 -238 -143 1942 2 180 -3440 11 178 370 11 178 370 11 178 1960 14 180 60 19850 11 281 60 11 28 60 79850 41 28 60 79850 41	SSES-TITANIUM 0 0 0 6 272 233 296 -932 -1413 -238 -143 1942 2 180 -3440 11 178 370 11 178 370 11 178 1960 14 180 60 19850 11 281 60 11 28 60 79850 41 28 60 79850 41	SSES—TITANIUM Codecontact (nat. area = 0 a. c. c. c. c. c. c. c. c. c. c. c. c. c.	SSES—TITANIUM Codeconactivations of 42 221 233 935 1880 2841 296 -932 -704 1752 2.727 296 -932 1890 2841 297 239 15-6 2-56 213 1810 2-64 3215 216 -1440 11600 27,770 42,770 217 22 1134 25,84 3218 21 22 1150 240 43,58 64 21 24 1952 26,77 42,048 21 23 1150 21,344 25,848 21 23 1150 21,344 25,848 22 1134 25,848 64,388 64,388 22 1134 25,848 64,388 64,388 22 1134 25,848 64,388 64,388 22 27 27 27 27 28 28 28 28 28 28 28 28 28 28 28 28 28	SSES—TITANIUM Codoconactivaries - 0 428 0 0 0 60 135 210 244 221 233 935 1380 2841 -966 -932 -204 1752 2,227 -180 -347 332 13.06 4000 128 370 11562 24,000 27,323 66 10 0 14,019 31,542 49,006 67,004 16 10 0 16,000 27,170 42,770 69 1128 370 11562 24,000 57,004 51 128 1156 1136 2540 33,840 43,786 4000 128 129 1136 2540 32,840 43,786 86,840 16 129 129 129 129 129 129 129 129 129 129	SSES—TITANIUM Coldwormer Array Coldwormer Coldwo	SSES-TITANIUM Coldwormer Array Coldwormer Coldwo	SSES—TITANIUM Coldwormer Array Coldwormer Coldwo	SSES—TITANIUM Coldwormer Array Coldwormer Coldwo	SSES-TITANIUM	Code-condition Code	SSES-TITANIUM Codemonated inversers - 0.428i Codemonated inversers - 0.428i Leg kp kp kp kp kp kp kp kp kp kp kp kp kp	SSES—TITANIUM Codeworks of rise 1 and 1 a	SSES-TITANIUM A CONCHANGE (form trans. * 0.428) O	SSES-TITAMIUM Colomonical final aria = 1	Control Cont

PHASE II -TASK 4_ APPLICATION AND PROCESS PARAMETERS

300 M, C.W. net fit, Hr. Lok. sleeve process. 110 ksi

TEST_4A1 SPECIMEN 623080 DATE 11/13/73

SPECIMEN DESCRIPTION	TION	COLDWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS	S
Configuration	Fig. 2	Interference (IR.)	0.018	Nominal hole 1776 (ii)	0.375	Man not stress theil	110
Material	300 M steel (220-300 ksi) Steeve 1ype	ksi) Steeve type	Split	Process	Ream, C/W, ream	Max rest load (kip)	313
Width (m.)	1.50	Sieeve thickness (in.)	90.010			Load ratio IR)	0.1
Hole spacing (in.) 1.50	1.50	Steeve orientation	0,			Test frequency	4000 cpm
Edge margin (in)	0.75	Mandrel material	AISI 9260	FASTENER INSTALLATION	TION	Fest laboratory	Materials
Material gage (+n.)	0.250	Mandret taper (in /in)	0.045	TVDE	Hi-Lok, pror hd	Test engineer	D. Reese
Surface treatment	Shot peen	Mandret max diameter (in 1.0.3525	^b 0.3525	F11 [10.]	Net to 0.0005 clearance	Test machine	100-kip Vibraphore
		Lubrication	Fet P10 300	Torque (in 1b)	240.250		

^bMandrel size reduced to 0.3513 after two holes; stabilized at 0.3510 after three holes

^aSleeve thinout was 0.002 in.

Origin of failure	and remarks		C-W Hd			PH					W.S.		
Cycles	to fariure	93,000				280,000				178,000			
Fastuner size (in)	f.1	Net	Z			0.0005	0.0005			Net	Net		
Fastuner	Diameter	0.3740	0.3740			0.3740	0.3740			0.3740	0.3740		
Coldwork expansion tin 1	Heraines	0500.0	0.0050			0 0045	0 0045			0.0045	0.0045		
(Co)	Actual	0.0123	0.0123			0.0120	0.0120			0.0120	0.0120		
=	After	15	;			20	1			15	١		
HOLE LIN Sh (RHIR)	Atter	10	1			10				10			
Ĭ	Before	20	ı			20				20			
_	After	0.3740	0.3740			0.3745	0.3745			0.3745	0.3745		
Hole (hameter (in.) Hole tin sh (HH)R)	After	0.3600	0.3600			0.3595	0 3595			5658.0	0.3595		
Ĭ	Before coldwo k	0.3550	0.3550			0.3550	0.3550			0.3550	0.3550		
3	ę	-	2	3	4	,	2	3	4	_	2	3	4
Specimen	desp or	2)				.22				.23			

CATION AND PROCESS PARAMETERS

C/W net fit Hi-Lok, sleeve process.	Max rest toad (kip) 31.3 Max rest toad (kip) 31.3 Load ratio (R) 0.1 Test frequency 4000 cpm Test taboratory Materials Test engineer D. Reese Test machine 100 kip Vibraphore	
PHASE II -TASK 4 - APPLICATION AND PROCESS PAHAMETERS TEST 4A2 SPECIMEN 623080 DATE 11/13/73	0.018 Nominal hote size (in 0.375	
PHASE II -TASK	SPECIMEN DESCRIPTION Configuration Fig. 2 Interference (in.) Material 300 M steel (270-300 ksi) Hote spacing (in.) Edge margin (in.) Edge margin (in.) O.250 Mandrel taper (in.) Surface treatment Shot peen Lubric Alon Lubric Alon	
	SPECIA Don Wid Wid Hole Edg	

Origin of failure	and remarks	- H	1		*	L'AN HO	2			L Hd			
Cycles	failure	103,000				128,000				114,000			
Fasterver size (in 1	Fit	Net	Net			Net	Net			Net	Ner	 - -	
Fastener	Diameter	0.3740	03740			0.3740	03740			0.3740	0.3740		
Cotdwork	Refained	0.0045	0.0045			0.0050	0.0050			0 11050	05000		
Cotd	Actual	0.0120	0.0120			0.0120	0.0120			0.0125	0.0125		
í.	Alter	15				29	i			15			
Hale tinish (RHR)	After coldwork	10	1			10	į			15	,		
Ť	Before	20	,			20				25	:		
,	After	0.3740	0.3740			03740	0.3740			0.3740	0.3740		
Mole diameter (in)	After	0.3595	0.3595			0.3600	03600			0.3595	0.3595		
H	Before	0.3550	0.3550			0.3550	0.7550			0.3545	0.3545		
	10 P	-	2	3	4	_	2	3	4	-	2	8	4
Sperimen	de or	.24				.25				25			

PHASE II - TASK 4 - APPLICATION AND PROCESS PARAMETERS

300 M, C/W only, open, 110 ksi

The second of th

SPECIMEN 623080 DATE 9/7/73 TEST 4A3

110	4000 срт	Materials	D. Reese	2	100-kip vibraphore	
FATIGUE CCNDITIONS Man net stress (kg) 110 Man test load (kip) 0.1	Load ratio (R)	Test feequeency	Test fationarony	Test engineer	for marine	
3/8 Ream, C/W			₹ 0			
HOLE PREPARATION Naminal hale size (in) Process			Carbide (BAC 5972) FASTENER INSTALLATION	T v P.e	Fit	Torque (in lb)
0.073 Push, no steeve		1	Carbide (BAC 5972)	0.030	0.353	Fel Pro 300
COLDWORK PROCESS Interference (in.) Steeve type	Sieeve thickness lin !	Steeve orientation	Mandrel material	Mandrel taper (in /in)	Mandrel max diameter ini.) 0.353	Lubrication
Configuration Fig. 2 Configuration Fig. 2 Material 300 M steril 1270-300 ksi)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION Configuration F Material 300 M steel I	Width (in)	Hole spacing (in.)	Edge margin (in)	Material gage (in)	Surface treatment	

Origin of failure	and remarks	- C]		-> 8				→ (
Cycin	o, arunte	428,000				788,000				206.000			
1 to 1 a/15	F -3												
fastaner size In 1	Dameter												
Coldwork expansion (in)	Retained	0.0155	0.0155			0.0155	0.0155			0.0155	0.0155		
Сон	Actual	0.023	0.023			0.023	0.023			0.023	0.023		
8	Atter	-	_										
Hote linish (RHR)	Africa	10	1			15	ı			10	,		
Î	Before coldwork	20	-			25	ı			20			
	Ane												
Mole diameter fin i	After	0.3505	0.3505			0.3505	0.3505			0.3505	3505		
, ž	Butore	0 3350	0.3350			0.3350	0.3350			0.3350	03350		
1		-	2	3	4	-	2	3	4	-	2	3	4
Specimen	5 S	12.				-28				.29			

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	\				4000 com	Mariana M		O. neces	DO-KID AIR SPIN	
300 M. open, C/W. scored	IIO KSI	FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio IR)	Test frequency	Test lattoratory	Tast engineer	Test machine	
PHASE II -TASK4 - APPLICATION AND PROCESS PARAMETERS	SPECIMEN 623080 DATE £17/73	HOLE PREPARATION	Noming hate size (in) 3/8	Mocess Ream, C/W. ream score			FASTENER INSTITLATION	Type	Fit	Torque (in :lb)
APPLICATION	444		0.023	Push, no sleeve			Carbide (8AC 5972)	6.030	(i.e.) 0.358	Fel Pro 300
PHASE II -TASK4	16.51	COLDWORK PROCESS	Interference (in.)	Sleeve type	Sleeve thickness (in)	Sleeve orientation.	Manthel material	Mandrel taper (in I/n.)	Mandrel max diameter (in). 0.358	Lubrication
		SPECIMEN DESCRIPTION	Configuration	Material 300 M (270-300 ksi)	Width In 1	Hole spacing (in.) 1.50	Erigi margin (in ! 0.75	Material gage (in.). 0.250	Surface treatment Shot peen	

f tailure	and remarks	{	Φ										
Origin of failure	and re	-		_		→ 0		- 		 •			
Cycles	failure	103,000				67,000				110,000			
Fastener size (in)	F.d										-		
Fastener	Diameter												
Coldwork expansion (in)	Retained	0.0145	0.0150			0 0150	0.0150			0.0145	0.0145		
Cold	Actual	0.023	0.023	į		0.023	0.023			0.023	0.023		
2	After	20	20			75	25			2	2		
Hole finish (RHR)	After	15				10	i			15	:		
l ŝ	Before	25	1			25				25	1		
	After	0.3735	0.3735			0.3740	0.3745			0.3735	0.3735		
Hole diameter (in)	After	0.3495	0.3500			0.3500	0.3500			0.3495	0.3495		
Ť	Before	0 3350				0.3350	0.3350			0.3350	0.3350		
	J S	-	2	2	4	-	2	8	4	_	2	3	7
	Specimen	ş	3			5				.32			

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	TEST.	TEST 4A5 SPECIMEN	SPECIMEN 623380 DATE 10/11/73	<u>(73</u>	110 ksi	
SPECIMEN DESCRIPTION	COLDWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS	
Configuration Fig. 2	Interference	0.023	Nominal hole size (in.)	3/8	Max net stress (kgs)	110
300 M steel (270 300 ksi)	Sieve type	Push, no sleeve	Process	Drill, C/W, ream	Max rest load (Kip)	31
Width (m.)	Sleeve thickness (in.)	i			Load ratio (R)	0.1
Hole spacing	Sleeve orientation	:			Test frequency	4000 cpm
Edge margin (in) 0.75	Mandrel material	Carbide (BAC 5972)	FASTENER INSTALLATION	-	Test laboratory	Materials
Material gage tin 0.250	Mandrel taper (in in)	9.030	7 yes		Test engineer	D. Reese
Surface treatment	Mandrel max diameter (in.) _	0.357	F		Test machine	100-kip Vibra
	Lubricition	Fel Pro 300	Torque (uv. tb)			

	and remarks	->	€		}		\$5						}
Cvclms	to failure	266,000				152,000				252,000			
Fastener size (in)	F.1												
Fastener	Diameter												
Coldwork expansion (in)	Retained	0.0135	0.0135			0.0135	0.0135			0.0135	0.0135		
Cold	Actual	0.0225	0.0225			0.0225	0.0225			0 0225	0.0225		
æ	After	39	'			98	i			35] .		
Hole finish (AHR)	After	15				01				15			
Ĭ	Before	6	;			40				40			
1.1	Afrer	0.3735	0 3735			0 3740	0 3740			0.3735	0.3735		
Hole diameter Inc.)	After	0.3480	0.3480			0.3480	0.3480			03480	0.3485		
Ĩ	Byfore coldwork	0.3345	0.3346			0 3345	0.3345			0 3345	0 3345		
H Sign	00	-	2	3	٠,	-	2	3	4	-	2	65	77
Specimen	960 96	9.				7				8			

300 M. abusive driil. open, C/W	110 ksi	FATIGUE CONDITIONS	Max ner stress that	Mar test load (Kip)	Load fails in 400 cpm	Materials	D. Rece	100-kip vibraphore	Test machine	
ND PROCESSPARAMETERS	623080 DATE 10/11/73	HOLE PREPARATION	Nominal hole size (in) 3/8	Process			FASTENER INSTALLATION	Type	F.19	Torque (in 1b)
PHASE II-TASK 4- APPLICATION AND PROCESSPARAMETERS	TEST 4A6 SPECIMEN 623080	COLDWORK PROCESS	Unterference 0.023	Steeve type	Sleeve thickness (in)	Sleeve orentation	Manufel malidal Carbide (BAC 5972)	Mandret taper (in /m) 0.030	Mandrel max diameter (m.) 0.357	Lubricition
		SPECIMEN DESCRIPTION CC	Contiguration Fig. 2	Material 300 M steel (270-300 ksi)	Width (in)	Hole specing	Edge margin lin) 0.75	Material gage (in.)	Surface treatment Shot peen	

Origin of failure	and remarks	-	CW					+ 3)	_	}	C.w				
Cycles	failure	113,000				_	80	000,000				380,000					
Fastener size (in)	<u>.</u>													-		-	
Fastener	Diameter																
Coldwork expansion In I	Retained	0.0135	3	0.0140				0.0120	0.0125			96000	1000	0.00145			
Cold	Actual	0.000		0.022				0.020	0.021			0.017		0.022			
2	Altır	۶		-				15				 5	;	1			
Hole finish (RHR)	After	٤	2	1				51				٤	2	1	 _	 -	
ੀ 	Before	3	8	,				S		 		8	3	1		 	
	After		03/30	0.3730	 !			0 3735	100	0.37.35			0.3730	0.3735		 -	
Hole diameter (in)	Attor	COICINOLE	0.03485	0.03490				0.3490		0.3490			0.3495	0.3495			
Hol	Betore	colemori	0.3350	0.3350				0.3370		0.3360			0 3400	0.3350			
	a o		-	7	3		4	-		7	٣	,	_	,		m	4
	Specimen dash no		ġ.					5	2	-			÷				

PHASE II -TASK 4- APPLICATION AND PROCESS PARAMETERS

DATE 10/11/73 SPECIMEN 623080 TEST 4A7

黒いこ 野県 6

#1 12 13

SNO	110	30.7	0.1	4000		Materials	100 kip Vibraphore	
FATIGUE CONDITIONS	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Max one load (bio)	divided to be d		Azi meduency	rest laboratory	l est engineer Test machine	
HOLE PREPARATION F	Nominal hole size (in.)	Process Ream, C/W, ream (25/64)			CACTENED INCTALLATION	T.C.	F=	Torque (in lb)
	0.023	Push, no sleeve		-	Carbide (BAC 5972)	0.030	0.358	Fel Pro 300
COLDWORK PHOCESS	Interference	Sleeve type	Sleeve thickness (in.)	Slewe or untation	Mandrel material	Mandrei taper (in./in.)	Mandrel max diameter (in) 0.358	Lubrication
RIPTION	Fig. 2	300 M steel (270-300 ksi)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material	Width (in)	Hole spacing	Erige margin (in.)	Material gage (in)	Surface treatment	

Torque (in lb)

	\$ 5 2		}	₹ (*)	,		})		{	4	, (
	Origin of failure and remarks		CW	•			CW	44			N'S		
Cvclix	farture	65,000				45,000	3			50,000	000,000		
Fastener size tin)	F.												1
Fastener	Diameter												
Colifwork excension In 1	Retained	0.0155	0.0155			0.0155	0.0155	-		0.0155	0.0165		
Ser	Actual	0.0235	0.0235			0.0235	0 0235			0.0235	0.0235		
r	After	8	-			8	i			æ	R		
Hale finish (RHR)	Allm coldwork	15				15				10	-		
Ĭ	Before	25	:			25				8		+-	
-	After	0.3895	0.3895	!		0 3895	0.3895			0.3900	0 3900		
Hole diameter (in)	After	0.3500	0.35.00			0 3500	0.3500] 		0.3500	0.3510		
Ĭ	Before	0.3345	0.3345			0 3345	0.3345			0.3345	0.3345		
Hole	۶	-	2	٣	4	-	2		4	-	2	۳.	4
Specimen	٤	-33				34				35			_

PHASE II-TASK 4- APPLICATION AND PROCESS PARAMETERS

300 M, 1/32-postream, 110 ksi

TEST 4AB SPECIMEN 623080 DATE 10/11/73

SPECIMEN DESCRIPTION	NOI	COLDWORK PROCESS		HOLE PREPARATION	FATIGUE CONDITIONS	S.
Configuration	Fig. 2	Interference	0.023	Nominal hole size (in) 3/8	Max net stress (ks)	110
300 n	300 M steel (270-300 ksi)		Push no sleeve	Process Ream, C/W, ream (13/32)	Max test load (kip)	30.3
120	1.50	Coll stage and average	•		Load ratio (R)	0.1
	1.50	Section of the contract of the	ļ		Test frequency	4000 cpm
Biologic III	0.75		Carbide (BAC 5972)	CACTEMED INSTALLATION	Test laboratory	Materials
cope region (in)	0.250	Manual material	0.030	Tura	Test engineer	D. Reese
Surface prestment	Shot peen	Mandrel max dameter (m) 0.358	0.358	14		100-kip Vibraphore
		Lubricition	Fel Pro 300	Torque (in. lb)		

Orign of failure	and remarks	_	WS W)		{	№ 3)		1	W ₂		
Cycles	10 Iailure	248,000				121,000				209,000			
Fastener size (in)	Fit												
Fastener	Diameter				: ! 								
Coldwork expansion (in)	Retained	0.0145	0.0145			0.0145	0.0145			0.0145	0.0145		
Colc	Actual	0.0235	0.0235			0.0235	0.0235			0 0235	0.0235		
8	After	02	82			02	8			2	1		
Hole finish (RHR)	After	15	1			10	1			12	1		
ĭ	Before	30	1			20	1			25	ı		
-	After	0 4055	0.4055			0.4055	0.4055			0.4055	0.4055		
Hole diameter (in.)	After	0.3490	0.3490			0.3490	0 3490			0 3490	0.3490		
<u>ਵ</u> ੇ	Before co-dwork	0 3345	0.3345			0 3345	0 3345			0 3345	0 3345		
	8	-	2	3	4	_	2	۳	47	-	2	3	4
Specimen	daed or	·36				37				38			

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					100 ks	KSI
	TEST	449	SPECIMEN 623080 DATE 10/12/73	7.12/73		
SPECIMEN DESCRIPTION	COLUWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS	SN
Configuration Fig. 2	Interference	0.023	Nominal hole size (in)	3/8	Max net stress (ks.)	011
Material 300 M (270-300 ksi-	Sleeve type	Push, no sleeve	Process Re	Ream, C.W. ream (7/16)	Max rest load (kip)	29.6
Width (in)	Sleeve thickness (in.)	1			Load ratio (R)	1.0
Hole spacing	Steeve or milation				Test frequency	4000 cpm
Edge margin (in) 0.75	Mandrel material	Carbide (BAC 5972)	FASTENER INSTALLATION	Z O	Fest tathoratory	Materials
Material gage (m.) 0.250	Mandret taber (in /in)	0.030	Type		Test engineer	D. Reese
Surface treatment Shot peen	Mandret max diameter (in).	0.358	F.t.		Test machine 10	100-kip Vibraph
	of sold in	Fel Pro 300	Torque (in 1b)			

Origin of failure	and remarks	-	W.S.			-	TO LOW COM)	-	The state of the s		
Cycles	failure	58,000				000'22				25,000			
Fastener size (in)	F.1												
Fastener	Ciameter												
Cordwort expansion (in §	Relained	0.0145	0.0145			0.0145	0.0145			0 0 1 4 5	0.0145		
Cold	Actual	0.0235	0.0235			0.0235	0.0235			0.0235	0.0235		
÷	Alter	25	1			30	_			52	1		
Hole finish (RHR)	Atter	12	١			15	-			15	1		
Ĭ	Before	25	÷			30	ı			30	ť		
-	After	0 4365	0 4365			04370	0.4370			04370	04370		
Holy diameter (in]	Affer	0 3490	03460			03490	0 3490			03490	0 3490		
H	Before	0.3345	0 3345			0.3345	0 3345			0 3345	0.3345		
i I	۶	-	2	3	q		2	۳	च	-	۲.	~	13
Specimen	de de la constant de	39				.40				14			

300 M, 0.060-in. gage mtl		FATIGUE CONDITIONS	Max net stress (ksi) 110	Max test load (kip) 3.6	Load ratio (R)	Test frequency 4000 com	Test laboratory Materials	Test engineer D. Roese.	Test machine 36 kip Vibraphore	
IND PROCESS PARAMETERS	623080 DATE 9/24/73	HOLE PREPARATION	Nominal hole size (in) 3/8	Process			FASTENER INSTALLATION	Type	Fit and a second	Torque (in ib)
PHASE II-TASK 4- APPLICATION AND PROCESS PARAMETERS	TEST 481 SPECIMEN 623080	COLDWORK PROCESS	Interference 0.023	Sleeve type	Sleeve thickness (in)	Sleeve orientation	Mandrel material Carbide (BAC 5972)	Mandrel taper (in /in.) 0.030	Mandrel max duameter (in) 0.358	Lubrication Fel Pro 300
ā.		SPECIMEN DESCRIPTION COL	Configuration Fig. 2	300 M steel (270-300 ksi)	Width Lin) 1.50	Hole specing 150	Edge margin (in) 0.76	Material gage (in) 0.060	Surface treatment Shot peen	

Origin of failure	and remarks	_ ;	5			_;	No.			_;	æ l		
Cycles	to failure	71,000				12,000				47,000			
Fastener size (in.)	Fit												
Fastener	Diameter												
Coldwork expansion (in)	Retained	0900.0	9600.0			0.0095	0.0085			00115	0.0125		
Colo	Actual	0.0235	0.0235			0.0235	0.0235			0.0235	0.0235		
æ	After	15	!			20	ı			15			
Hole finish (RHR)	After coldwork	12	l			15	1			01	 		
ĭ	Before coldwork	25	_			25				20			
_	After	0.3735	0 3735			0.3740	0.3740			0.3735	0.3735		
Hole diameter (in)	After coldwork	0.3405	0.3440			0.3440	0.3430			03460	03470		
Î	Before	0.3345	0.3345			0.3345	0.3395			0 3345	0 3345		
=====		-	2	3	4	_	2	3	4	-	2	~	4
Specimen	f oc	-				.2				3			

300 M. 1 hole, not C/W,	TITO ksi	FATIGUE CONDITIONS	Max net sterss (ksi)	Max test load (kip) 30.6	Load ratio (R) 0.1	Test frequency	Test laboratory Materials	Test engineer D. Reese	Test machine 100-kip vibraphore	
ND PROCESS PARAMETERS	623080 DATE 9/10/73	HOLE PREPARATION	Nominal hole size (in)	Process Hoie 1, ream	Hole 2, ream, C/W 1 ream		FASTENER INSTALLATION	Type.	Fit Net to 0.0005 clearance	Tarque (in. It.) 240.250
PHASE INTASK 4 - APPLICATION AND PROCESS PARAMETERS	TEST 4C1 SPECIMEN 623080	COLDWORK PROCESS	Interference 0.023	Sleeve type	Sheve (huckness (in)	Sieeve orientation	Mandret material Carbide (BAC 5972)	Mandrel taper (in /in)	Mandrel max diameter (in) 0.358	Lubricition Fel Pro 300
		SPECIMEN DESCRIPTION	Configuration Fig. 2	Material 300 M steel (270-300 ksi) Sleeve type	Width (in)	Hole spacing	Edge margin (i.)	Material gage (in.) 0.250	Surface treatment Shot peen	

Origin of Lature	and remarks	{			Failed in reamed hole				Failed in reamed hole	{			Failed in reamed hole
Cycla	to failure	43,000				52,000				33,000		 	
Fastener size lin J	Fit	0.0008	0.0005			0.0005	0 0005			NET	NET		
Fastener	Diameter	0.3735	0 3735			0.3735	0.3735			0.3740	03740		
Coldwork expansion (in)	Retainert	1	0.0145			_	0.0140			!	0.0140		
Cole	Actual	ļ	0.0235			l	0.0230			!	0.0230		
ā	Alter	8	25			93	20			ၕ	20		
Hole finish (RHR)	After	i	15				12			1	15		
Ĭ	Before		25			! !	25			!	8		
	After	0.3740	03740			0.3740	03740			0.3740	0 3740		
Hole diameter (in)	After	,	0.3497				0.3490			1	0 3490		
ř	Before		0 3345				0 3350			:	0.3350		
	ž č	-	2	٣	4	-	2	3	4	-	2	0	4
Control	dash	:42				.43				44			

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APPLICATION AND PROCES
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300 M, 0.002 clearance Hi-Lok,	TIOKS	TIONS	ks.l 110	kip) 31.3	0.1	4000 cpm	Materials	D. Reese	100-kip Vibraphore	
30.002 cles		FATIGUE CONDITIONS	Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer.	Test machine	
IND PROCESS PARAMETERS	SPECIMEN 623080 DATE 9/24/73	HOLE PREPARATION	Nominal hole size (in) 0.375	Process			FASTENER INSTALLATION	Type Hi-Lok, prot hd	F ₁₁ 0.002 clearance	Torque (in lb) 240-250
PHASE II-TASK 4- APPLICATION AND PROCESS PARAMETERS	TEST_4C2SPECIMEN_	COLDWORK PROCESS	Interference 0.023	Steeve type	Sleeve thickness (in.)	Sleeve or entation	Mandrel material	Mandrel taper (in /ic.) 0.030	Mandrel max diameter (in.), 0,358	Lubrication
		SPECIMEN DESCRIPTION	Configuration Fig. 2	Material 300 M steel (270.300 ksi)	Width (in) 1.50	Hole specing	Edge margin (in) 0.75	Material gage (in.) 0.250	Surface treatment. Shot peen	

or life to many	and remarks	-	C/W HD			1	C/W HD		Failed in grip		C/W HD		}
Cycles	to Tariore	000,117				254,000				283,000			
Fastener size (in.)	J. L.	0.002	0.002			0.002	0.002			0.002	0.002		
Fastene	Diameter	0.3735	0 3735			0.3735	63753			0.3735	0.3735		
Coldwork expansion (in)	Retained	0.0165	0.0165			0.0170	0.0155			0.0155	0.0155		
Coll	Actual	0.0245	0.0245			0.0245	0.0245			0.0245	0.0245		
æ	After	25	1			25				25	ı		
Hole finish (RMR)	After coldwork	01	1			15	1			0			
Ħ	Before	25	١			8				28	-		
[-	After	0.3755	0.3755			0.3755	0.3755			0.3755	0.3755		
Hole diameter (in)	After coldwerk	0.3500	0.3500			0.3505	0.3490			0 3490	0 3490		
¥	Before	0.3335	0.3335			0.3335	0.3335			0 3335	0 3335		
Hole	ę.	ı	2	3	4	1	2	3	4	-	2	3	4
Specimen	Ou Ou	.48				49				.50			

FASK 4 - APPLICATION AND PROCESS PARAMETERS
FASK4
HASEII -
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300 M, 0 002 interference Hi-Lok, 110 ksi		FATIGUE CONDITIONS	•	à	Tast feetings	-	-	161 ergineer 100-kip Vibraphore	Test michine	
	_DATE		0.375	Keam, C/W, rediti Max					<u>erferen</u> se	(b) 240.250
PHASE II -TASK 4 - APPLICATION AND PROCESS PARAMETERS	TEST_4C3 SPECIMEN_623080D	HOLE PREPARATION	0.023 Nominal hole size (in)	Push, no sleeve Process			Carbide (BAC 5972) FASTENER INSTALLATION	0.030 Type	r(m) 0.355 Futin.	Fel Pro 300 Torque (in lb)
PHASEII -TASK	TEST	COLUWORK PROCESS	Interference (in.)	300 M steel (270-300 ksi Sleeve type	Steeve thickness (in)	Sleeve orientation	Mandrel material	Mandrel taper (in /in)	en Mandrel max diameter (in) 0.355	Total District
		SPECIMEN DESCRIPTION	Configuration Fig. 2		1.50 Width (in)	Hole spacing (in.) 1.50	Edge margin (in) 0.75	Material gage (in) . 0.250	Surface treatment Shot peen	

Origin of failure		-	C/W Hd				-	() PH	7)		4-	C.W Hd				
Cycles	farore	2 202 000	3,282,000				3	198,000				000	249,000			-	
Fastener size (in)	ij	1 68	780	0 002				0 0005	0 0002				0 0005	0 005			
Fastene	Diameter		0 3730	0.3730				0.3730	03730				0.3730	03730			
Coldwork expansion (in I	Ristained		0.0155	0.0160	i			0 0 0 65	0.0165				0.0165	0.0165	_	+	
Cold	Actual		0.235	0 0235				0.0235	0.0235				0.0235	0.0235	ļ ļ_	-	
=	After		25	<u>'</u>				25					8	:		-	
Hole finish (AHR)	After		10	;				12		-			15	I			
Ho	Before		20					52					30				
_	After		0.3710	0 3710				03710		03730			0.3710	0.3710	2		
Hole diameter (in	After	COLUMNOL	0.3490	0.3500				0.3505		0.3505			0.3505	0 26 0	0.3303		
Į.	Betore	colchwork	0.3345	_				0 3345	Τ	0.3345			0.3345		0.3345		
	Por or		-	2	~	,	4	-	ľ	2	9	4	-	,		٣	4
	Specimen dash no		.45						7				7.8				

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300 M 100° cst. after C/W. 110 ksi

TEST 4C4 SPECIMEN 623080 DATE 9/28/73

10	110	31	0.1	4000 cpm	Materials	D. Reese	100 kip Vitraph	
FATIGUE CONDITIONS	Max net stress (ks.) 110	Ream, C/W, ream csk Mex test load (kip) 31	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	0.375	Ream, C/W, ream			ATION	Hi-Lok (100° hd)	Net to 0.0005 interference	240.250
HOLE PREPARATION	Nominal hole size (in)	Process			FASTENER INSTALLATION	Type	F.r (in.) Net	Torque (in 1b)
	0.023	Push, no sleeve	1	i	Carbide (BAC 5972)	0.030	m.) 0.357	Fel Pro 300
COLDWORK PROCESS	Interference (in.)	Sleeve lype	Sleeve thickness (in)	Sleeve of rentation,	Mandrel material	Mandrel taper (in lin) 0.030	Mandrel max diameter (in.) 0.357	Lubrication
	Fig. 2	300 M steel (270-300 ksi)	1.50	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material 300	Width (in)	Hole spacing(in.)	Edge margin { n }	Material gage (in). 0.250	Surface treatment	

Orian of fature	and remarks		PH CW		No failure		C/W HG		No failure		C.W.		}
Cycles	tauwe	000 866'6				7,760,000				1,510,000			
Fastener size (in)	f. 1	0.0005	0 0005			0.0005	Net			0 0005	0 0000		
Fastener	Diameter	0.3740	0 3740	!		0.3740	0.3740			G 3740	0.3740		
Coldwork expension (in.)	Retained	0.014C	0 0 1 4 0			0.0145	0510.0			0.0150	06100		
Cole	Actual	0.0230	0.0230			0.0235	0 0 2 3 0			0 0230	0.0230		
i i i	Alter	20					20			20	,		
Hole finish (RHR)	After coldwork	10	ı			:	20			12	ī		
Ĭ	Before coldwork	25	;			ı	40			25	!		
	After	0 3735	0.3735			0.3735	03740			0.3735	0 3735		
Hole diameter (in)	After	0.3480	0.3480			0 3480	0.3500			03490	0.3490		
¥	Before coldwork	0.3340	0 3340			0 3335	0 3340			0 3340	0 3340		
e id	ę.	-	2	3	4	-	2	3	-3	-	2	3	4
Specimen	ξę g	.51				-52				.53			

APPLICATION AND PROCESS PARAMETERS
- 1
PHASEII -TASK4

300 M. 70° csk after C/W. 110 ksi

SPECIMEN 623080 DATE 10/2:73 11 ST 4C5

100 kip Vibraphore 4000 cpm D. Reese Materials Max net stress lus.) 110 FATIGUE CONDITIONS Process Ream C/W ream CSK install fastener Max test load (kip) Test laboratory Load ratio (R) Test frequency Test machine Test engineer Type: Boeing radius lead-in, bolt (70° hd) Fig (in.) Net to 0.0005 clearance 240.250 3/8 FASTENER INSTALLATION Nominal field size find HOLE PREPARATION forque fin Itil Carbide (BAC 5972) Push, no sleeve Fel Pro 300 0.030 0.023 Manderel max chameter (in) 0.357 Mandrel taper Im (in) Sleeve thickness lind COLDWORK PROCESS Sierve Orientation Mandrel malerial Interference (in.) Sleeve type 300 M steel (270 300 ksi) Surface treatment Shot peen 0.250 F.g. 2 1 50 1.50 0.75 SPECIMEN DESCRIPTION

Hale spacing (in) Edge margin (in) Material goge lin)

Width (in) Material

Configuration

Orign of failure	and temans	DH H				LC.W Hd				LC.W		}	
5 40 4 3	failure	935,000				420,000				2,597,000	-	-	
Fastener size (in)	÷	Net	Š			Ner	Net	+		Set	ž.	; ; !	
Fastenet	Diametire	0 3810	0 3810	i		0.3805	0 3805			0.3810	0.3810	} 	
Coldwork expansion (in)	Roldenore	0 0145	0.0145			0 0175	C 0145			0.0155	0.0155		
Cold	Actual	0 0235	0 0235			0 0235	0 0235			0 0235	0.0235	\ \ \ -+-	
	D I I II	01	2			2	2			10	٥		
Hole limsh [RHR]	After	0	10			10	10			10	,		
¥	Before	25				25	5			20			
_	After	0.3810	0.3810			0 3805	0 3805			0.3810	0.3810	-	
Hole diameter (in)	Atter	0 3480	0.3480	i		0.3510	0 3480			0 3490	0.3490		
Hol	Before					0.3335	0 3335			0 3335	0 3335		
	Hole oo	-	2	3	• •	-	2	8	4	-	2	m	e
	Specimen dash no		3			5.5				56			

300 M. 100° csk before C/W. 110 ksi		Max net stress (ks.) Max ret load(kip) Load ratio (R) Test frequency Test statocatory Test engineer Test machine 100 kip Vibraphore
PHASE II -TASK 4 - APPLICATION AND PROCESS PARAMETERS	TEST_4C6 SPECIMEN 623080 DATE 9/24/73	SPECIMEN DESCRIPTION Configuration Configuration Material 300 M steel (270-300 ks) Edge margin (in) Configuration Hole spacing (in) Configuration Mandrel max diameter (in) Configuration Fig. 2 Interference (in.) Push, no steeve Princes Push (in.) 3/8 Push (in.) 3/8 Push (in.) 3/8 Push (in.) 1/8 Pus

	Origin of failure		-	C.W.				4	C.W Hd						M.3				
	CVC 3	tailure m	80 80	330.88				200	70,000					36,000	<u></u>	 			
~	Fastener size fin l			Nei	Ned			}	Sec	Net				Net	1072	! ! !		1	
	Fasterier	Diameter		0.3740	0.3740				0.3740	03740				0.3740	20200	5.50			
	Coldwork expansion (in l	Refainert		0.0155	0 0170				0 0165	0.0165				0.0180		200			
,	rion roadka	Actual		r 0235	0 0235				0.0235	0.0235	2			0.0235		0.0235	-		
	~~~	Afrer		25	_				2		:			×	3 <u> </u>	<u> </u>	-		
	Hole finish (RHR)	After		10	1				10					5	2	-			
	Ĭ	Before	COLOMOTA	25	:				52	1	•			}	\$   	:	1		
		Afta	useau	0.3740	03740		1		0 3740		0.3740				0.3740	0 3735			
	Hole diameter (in )	After	cordwork	0.3495	0 2505	222		;	0.3500		0.3500				0.3515	0.3515		     	
	Hol	Betore	CONDINORK	0 3335	0 2225	0.3333			0.335	2222	0.3345				0 3335	0 3335	ļ 	1	
		io E		-	2	,	ຶ່	4	-		۲,	5	ļ	.	-	~: 	~	,	
		Specimen		3	2				:	2	_				41.				

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· xi				37.6		4000 cpm	Maid dis	D. Reese	100-kip Vibraphore	
prefatigued, 80,000 cycles, 110 ksi		FATIGUE CONDITIONS	Man net stress (ksi)	Max rest toart (kip)	Load ratio (R)	Test frequency	Test fahoratory	Test engineer	Test machine	
	16/73		3/8	Ream undersize,	C/W, ream		NOI	Hi-Lok prothd	Net to 0.0005 clearance	240 250
	623080 DATE 10/16/73	HOLE PREPARATION	Nominal hole size (in )	Process			FASTENER INSTALLATION	T y \$200	Fir (in.) Net	Torque (in th)
PHASE II - I ASN 4	TEST_4C7 (S) SPECIMEN 623080		0.023	Push, no sleeve		i	Cartude (BAC 5972)	0.030	(m.) 0.357	Fel Pro 300
PHASEII – I ASK 4	1651	COLDWORK PROCESS	Interference (in )	Steve type	Stepar Thu kness (m.)	Sureye of tentation	Mandel material	( ui, ui) sadet faskingkl	Mandrel max d ameter (m.)	20 T
			F.g. 2	300 M steel (270:300 ksi)	1.50	150	0 75	0.250	Shot peen	
		SPECIMEN DESCRIPTION	Configuration	Material 300	Width In )	Hote spacing (in.)	Con Constant	( Sel all all all all all all all all all a	Surface freet nent	

		Ï	Hote diameter (m.)	=	110	Hole finish (RHR)		Š kom	Coldwork expans on tin I	Fastener	Fastener size lin l	Cycla	Origin of failure
Specimen dash no	ž Š	Before col twork	After	A fur	Betare	After	After	Actual	Heraineri	Diameter	F.1	failuft	and remarks
7.	-	0 3330	0.3490	03735	92	10	20	0 024	0 0160	0 3735	Net	343,000	₩ H
?	2	0 3330	0.345:	0.3735		10		0.024	0.0155	0.3735	Net		<b>b</b>
]	3												
	4												}
51 15	-								<u> </u>				
	^	1									 		
	~								-	-			
	4								_				•
2	-	0.3330	0 3490	0.3735	20	01	25	0.024	0.0160	0 3735	Net	7,508,000	PH
	~	0 3330	0 34%	0.3735			 	0.024	0 0 160	0.3735	Net		
	~	ị   <del> </del> -		!					!			-	
				!		<u> </u>							No failure

RS	
RAMETE	
<b>ND PROCESS PARAMETERS</b>	-
A AND PR	
APPLICATION AND PI	
(4 - A	
I - TAS	
PHASE 11	

300 M	1%-D edge margin,	110 ksi	
HOCESS PARAMETERS			

0.023
Sheeve type  Sheeve that kness lin   Carbide (BAC 5972)  Mandrel material   Carbide (BAC 5972)  From the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of the line of t
Push no sleeve Process Ream C/N ream
Push no sleeve Process Ream C/W ream
Push, no sleeve Process Ream, C/W, ream
0.023 Nominal hole size (in I

	<del>-</del>	5	- 6	<u> </u>	7	7		5	7	5		5	7
600	s y	{	Ę	<u> </u>	}	}			]	}	<u>,                                    </u>	P P	}
Orient of fastice	and remarks	->	CW		-	->	CW				CW		
Cycles	10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to 10 to	100,000				170,000				177,000			
Fastener size lin )	Ę												
Fastener	Diameter												
Coldwork expansion (in )	Retained	0 0140	0.0140	0 0 1 4 0	0.0140	0.0135	0.0135	0 0135	0 0135	0.0150	0.0150	0.0150	0.0150
Coli	Actual	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0 0225	0.0225	0.0230	0.0230	0.0230	0.0230
۴)	Atim	15	_	_		10	·	1	ı	15	ļ.		į
Hole finish (RHR)	After coldwork	10	_	1		10		-	I ,	10	ı	i	-
H	Before	25	1			25	-	-		30	÷	1	:
1	After	0 3735	0.3735	0.3735	0.3735	0.3735	0 3735	0.3735	0 3735	0 3735	0 3735	0.3735	0 3735
Hote thameter (in )	After colidwork	0 3485	0.3485	0.3485	0.3485	0.3480	0 3480	0.3480	0 3480	0.3490	0.3490	0.3490	0 3490
ř.	Before co:dwark	0.3345	0.3345	0.3345	0.3345	0.3345	0.3345	0.3345	0.3345	0.3340	3.3340	0 3340	0.3340
Hote		-	2	3	4	1	2	~	ų	-	~	3	4
Specimen	Out Out	09				·61				. <del>6</del> 3			

PHASE II - TASK 4 - APP. CATION AND PROCESS PARAMETERS

DATE 10/22/73 SPECIMEN 623080 TEST 402 (S)

300 M, 2.D edge margin, 110 ksi

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100-kip Vibraphore 4000 cpm D. Reese Materials 75.7 FATIGUE CONDITIONS Max net stress (ksi) Max test load (kip) Load ratio (R) Test frequency Test laboratory Test machine Test engineer Ream, C/W, ream 0.375 FASTENER INSTALLATION Nominal hole size (iii.) HOLE PREPARATION Process F.11 Push, no sleeve Carbide (BAC 5972) 0.023.0.024 Fel Pro 300 0.030 Mandrel max diameter (in.) 0.357 Mandret taper for 'in t eeve thickness had Siegve Orientation Mandrel material Interference (In.) COLDWORK PROCF Sigeve Lybe Material 300 M steel (270 300 ksi) 150 x 2.00 Shot peen Fig. 78 0.750 0.250 3.50 SPECIMEN DESCRIPTION Hole spacing (in.) Material gage (in ). Eige margin (in ) Surface treatment Configuration Width (in )

Torque Inn. Its

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Orace of feel as	ond remarks		}		}	{			Nore	{			lure
		-				-	<u>≽</u>		Grip fature		ا ج ن	_	Grip failure
Cycles	to faiture	78,000				44,000				26.000			
Fastener Size (in )	u.							   					
Fastener	Diameter												
Coldwork expansion (in )	Retained	0.0150	0 0 1 5 5	0.0150	0.0150	0.0155	0.0155	09100	0.0150	0.0145	0.0145	0 0 1 4 5	0.0145
su <b>e</b> dxa ajoj	Actual	0 0735	0.0235	0.0235	0.0235	0.0235	0 0235	0 0235	0.0235	0 0 0 3 0	0 0 2 3 0	0 0 2 3 0	0.0230
	After	75		30	i	20	t	15	:	2)	-	25	1
Hate Linish (RHR)	Atter	10	1	10	:	15	1	10	1	15	-	10	-
Ť	Before coldwork	25	-	20		30	-	52	:	30		25	-
-	Alter	0.3735	0.3735	03/35	0.3735	0.3735	0.3735	0.3735	0.3735	03730	0.3730	03730	03730
Hole diameter (in )	Alter	0 3485	0.34(4)	0.3485	0 3485	0.3490	0.3490	0.3485	0 3485	0.3485	0.3490	0 3485	0 3485
Ĭ	Before	0.3335	0 3335	0 3335	0 3335	0.3335	0 3335	0 3335	0 3335	0.3340	0 3340	0.3340	0 3340
Hore	n0	-	2	c)	ų	-	C:	Ę,	7	-	۲۰	3	7
Sperings	ou ou	.65				.66				.67			

PHASEII -TASK4- APPLICATION AND PROCESS PARAMETERS

	PHASEII -TASK4-		APPLICATION AND PROCESS PARAMETERS	RAMETERS	300 M.	
					2½.D edge margin,	
	TEST 403 (S)		SPECIMEN 623080 DATE 10/23/73	3/73		
SPECIMEN DESCRIPTION	COLDWORK PROCESS		HOLE PREPARATION		FATIGUE CONDITIONS	
Configuration Fig. 7C	Interference (in.)	0.023.0.024	Nominal hole size (in )	0.375	Max net stress (ks) 110	
Material 300 M steel (270 300 ksi)	Sleeve type	Push, no sleeve	Process	Ream, C/W, ream	Max test load (kip) 86	
Width (in ) 3.875	Sleeve thickness (in )	ı			Load ratio (R) 0.1	
Hale specing (in.) 150 x 2.00	Sieeve orientation	i			Test frequency 4000 cpm	
Edge margin (in ) 0.937	Mandret material Carb	Carbide (BAC 5972)	FASTENER INSTALLATION	Z	Test laboratory Materials	
Material gage (in.) 0.250	Mandrel taper (in /in.)	0.030	Type		Test engineer D. Reese	}
Surface treatment Shot peen	Mandrel max diameter (in ). 0.357	0.357	Fit		Test machine 100-kip N	100 kip Vibraphore
	Lubricition	Fel Pro 300	Torque (in 1b)			

Oronin od Lashura	and remarks	}	CW			{	CW		}	->	CW		
Cycles	to failure	70,000				72,000				182,000			
Fastener size (in )	<b>J</b>												
Fastener	Diameter												
Coldwork expension (in )	Retained	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145
Colo	Actual	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
d)	Atter	20	ı	ı	-	15	1		i	20	1		•
Hole finish (RMR)	After	10	1	_	1	10		i	1	10	,	I	'
¥	Before coldwork	25	-	_	-	30	_	ı	ı	30	-		ı
-	After	0.3735	0.3735	0.3735	0 3735	0.3735	0 3735	0.3735	0.3735	0.3740	0.3740	03740	03740
Mole diameter (in	After coldwork	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3435	0.3485	0.3485
HC	Before	0.3340	0.3340	0.3340	0.3340	0.3340	0 3340	0.3340	0.3340	0.3340	0.3340	0.3340	0.3340
Ho!e	۶	1	2	3	4	-	2	2	7	-	2	3	4
Specimen	0 O	88				69				.71			

PHASE II -TASK 4 - APPLICATION AND PROCESS PARAMETERS

300 M, 2%-D edge margin, 110 ksi

SPECIMEN 623080 TEST 404 (S)

S	110	618	0.1	4000 cpm	Materials	D. Reese	100-kip Vibraphore	
FATIGUE CONDITIONS	Max net stress (ks.) 110	Mex test load (kip) 61.8	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	0.375	Ream, C/W, ream			NO			
HOLE PREPARATION	Nominal hote size (in )	Process			FASTENER INSTALLATION	Type		Torque (in. lb)
	0.023 0.024	Push, no sleeve		1	Carbide (BAC 5972)	0.030	0.357	Fel Pro 300
COLDWORK PROCESS	Interference (in.)	Sleeve Type	Seeve thuckness (in.)	Sleeve orientation.	Mandrel material Ca	Mandret taper (in./in.)	Mandret max diameter (in.)	Lubrication
NOIL	Fig. 70	300 M steel (270.300 ks)	2.995	Hole spacing (in.) 1.125 x 1.50	0.9375	0.250	Shot peen	
SPECIMEN DESCRIPTION	Configuration	Material 300 N	Width (in ]	Hole spacing (in.)	Edge margin (in )	Material gage (in.)	Surface treatment	

		(			7	7	- (	<u></u>	)	7		 la	 7
٩		{		>		}	<u>(</u>	5		{		γ <u>}</u>	}
Origin of failure	and remarks			]		i	ē	7				]	
ě	•		•								- A		
ļ 		-	3					_		>-	جَ ا		<b></b>
Cycles	to faiure	91,000				80,000				116,000			
Fastener size (in )	Fil												
Fastener	Diameter												
Coldworn expansion (in )	Retained	0.0150	0.0150	05100	0.0150	0.0150	0.0150	0.0150	0.0150	0 0 1 4 5	0.0145	0.0145	0.0145
Coto	Actual	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0230	0.0230	0.0230	0.0230
8	After	20	_	_	_	25	_	-	I	20	_	ı	_
Hofe finish (RHR)	After coldwork	10	ţ	-	1	10	_	•	_	10	I	-	_
Ŧ	Before coldmork	25	-	1		25	-	_	_	25	1	-	_
	After	0.3740	0.3740	0.3740	0 3740	0.3745	0.3740	0.3735	0.3735	0.3735	0.3735	0.3735	0.3735
Hote diameter (in.)	After	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485
£	Before coldwork	0.3335	0.3335	0.3335	0.3335	0.3335	0 3335	0.3335	0.3335	0.3340	0.3340	0.3341)	0.3340
9	۶	-	2	3	4	1	2	3	4	1	2	3	4
Specimen	<b>§</b> 8	21.				.73				.74			

and the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second of the second o

PHASE II -TASK 4 - APPLICATION AND PROCESS PARAMETERS

300 M, 2½.D edge margin, 110 ksi

| 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 1985年 | 198

TEST 405 (S) SPECIMEN 623080 DATE 10/23/73

110	72.2	0.1	4000 cpm	Materials	O Reese	IOU-KID VIDIADHORE	
Max net stress (ksi)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
0.375	Ream, C/W, ream			20			
Nominal hole size (in )	Process			FASTENER INSTALLATI	Type	F.1	Torque (in ilb)
0.023 0.024	Push, no sleeve		1	Carbide (BAC 5972)	0.030	(m) 0.357	Fel Pro 300
werterence (in.)	Sleeve type	Sleeve thickness (in )	Steeve or entation	Manifrel material	Mandrel taper (in )	Mandrel max diameter	Lubricition
Fig. 7E	steel (270-300 ksi)	3.375	150 x 1.50	0.9375	0.250	Shot peen	
Configuration	Mater .51 300 M	Wedth (i.o.)	Hole spacing (in.)	Edge margin (in )	Material gage (in.)	Surface treatment	
	ig. 7E October (in.) 0.023.0.024 Nominal hale size (in.)	ig. 7E   Interference (in.) 0.023.0.024   Nominal hale size (in.) 0.375   I. (270.300 ksi)   Sieeve type   Push, no sleeve   Process   Ream, C.M., ream	19.7E Interference (in.) 0.023.0.024 Nominal hale size (in.) 0.375 Max net stress (ksi) 1.(270-300 ksi) Steeve type Push, no sleeve Process Ream, C.W. ream Max test load (kip) 1.375 Steeve thickness (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100 (in.) 1.100	19.7E         Interference (in.)         0.023.0.024         Nominal hale size (in.)         0.375         Max net stress (ks)           1 (270.300 ks)         Steeve type         Push, no steeve         Process         Ream, C/W, ream         Nax next load (kip)           3.375         Steeve thickness (in.)	19.7E         Interference (in.)         0.023 0.024         Nominal hale size (in.)         0.375         Man net stress (ksi)           1 (270-300 ksi)         Steeve type         Prox ess         Prox ess         Ream, C/W, ream         Nax next load (kip)           375         Steeve type         -         Load ratio (R)           50 x 1.50         Steeve or instation         -         Test frequency           .9375         Manifel matrial         Carbide (BAC 5972)         FASTENER INSTALLATION         Test laboratory	ig. 7E         Interference (in.)         0.023.0.024         Nominal hale size (in.)         0.375         Man net stress (ks)           11 (270-300 ks)         Steeve type         Push, no sleeve         Process         Ream, C/W, ream         Man rist load (kip)           375         Steeve thickness (in.)         —         —         Load ratio (R)           50 x 1.50         Steeve contaction         —         Test frequency           1.9375         Manifeel material         Carbide (BAC 5972)         F ASTENER INSTALLATION         Test laboratory           1.250         Mandrel taper (in. in.)         0.030         Type         Test lengineer	ig. 7E         Interference (in.)         0.023 0.024         Nominal hale size (in.)         0.0336         Man net stress (ks)           1 (270-300 ks)         Sherve type         Push, no sleeve         Process         Ream, C.M. ream         Man net stress (ks)           50 x 1.50         Sherve thick hars fin.)         —         —         Load ratio (R)           50 x 1.50         Sherve cumitation         —         Test frequency           1.9375         Manifeel mater (in. in.)         0.030         Type           1.00         That engineer         Test machine           1.00         Mandrel max diameter (in.)         0.357         Fit

Origin of failure	and remarks	- Com				***							
Cycles	faiture	120.000				145,000				143,000			
Fastener size (in )	n. ti												
Fastener	Diametir												
Culdwork expansion (in )	Retained	0.0150	0.0150	0.0;45	0.0145	0.0160	0.0145	0.0145	0.0150	0.0150	0.0150	0.0145	0.0145
S GO	Actual	0.0235	0.0235	0.0230	0.0230	0.0230	0.0230	0.0230	0.0230	0.0235	0.0235	0 0230	0.0230
=	After	25	١	ı	1	20	-	-		15	<u>'</u>	1	
Hole finish (RHR)	After	20	ı	1	-	25	í	-	,	15	!	    -  -	-
Ĭ	Butore	45	ı	;	-	50	l	î	1	40		  -  -	'
	After	0.3735	0.3735	0 3735	0 37.35	0.3730	0 3730	03730	0.3730	0.3730	0 3735	03730	03730
Hole diameter (in	Alter co:dwork	0 3485	0.3485	0.3485	0 3485	0.3500	0.3485	0 3485	0.3490	0.3485	0 3485	0 3485	0.3485
Ĩ	B.:fore	0.3335	0 3335	0.3340	0.3340	0.3340	0.3340	0.3340	0.3340	0.3335	0 3335	0.3340	0.3340
	Hor or	-	2	3	4	-	2	3	4		2	٣	4
	dash	76				7.7				78			

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PHASE II-TASK 4- APPLICATION AND PROCESS PARAMETERS

300 M.
high load transfer,
C.W. net fit Hi-Lok
0.020 micarta,
110 ksi

and the state of the state of

SPECIMEN 623080

TEST 4E1

180 to 240 kip D. Reese Materials 600 cpm Riehle-Los 0.1 62 FATIGUE CONDITIONS Max net stress (ksi) Max test load (kip) Tirst frequency Test laboratory Load ratio (R) Test engumen Test machine Net to 0.005 interference Ream, CW, ream Hi Lok, prot hd 240.250 0.375 Carbide (BAC 5792) FASTENER INSTALLATION Nominal hale size (in.) HOLE PHEPARATION Torque for 1b) F.1 (in.) Process Push, no sleeve Fel Pro 300 0.030 0.023 Mandrel max diameter lin ) 0.357 Mandrel taper (in 'in ) COLDWORK PROCESS Sleeve thickness (in.) Sleme orientation Interference (if) Mandret material Sizeve type Lubrication 300 M (270-300 ksi) Shet elect Fig. 10 0.250 0.020 3.00 35. 0.75 SPECIMEN DESCRIPTION Material gage (in ) Surface treatment Edge margin (in.) Shim Thickness Configuration Hole spacing Width (in ) Material

Alter Actus 20 0.023 20 0.023 20 0.023 20 0.023 20 0.023 20 0.023 20 0.023 20 0.023 20 0.023				1					Cole	Culdwork				
After ream         Actual ream         Rectanned         F.1         failure         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual ream         Actual r	Hope digmeter (1) }	Hoje diameter (ii)	Sie diameter (ii)	~		ĭ	Hoir Linish (RHR)	_	uedx.	sion (in)	- astener	C 1 4 2 1 3	Cycles	Origin of failure
20 0.0235 0.0150 0.3735 0.0005 18.830	no Belore atter Atter Belore colowerk cel nork Learn colowork	atter After colon	Afre	-	Birtone coldwork		After	After	Actual	Retained	Diametir	۳. بر	fadore	and remarks
20 0,0235 0,0150 0,3736 Net Fasteners failed; side plate broad 0,0235 0,0150 0,3736 Net CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW Had CW CW CW Had CW CW CW Had CW CW CW Had CW CW CW Had CW CW CW Had CW CW CW Had CW CW CW Had CW CW CW Had CW CW CW CW CW CW CW CW CW CW CW CW CW	1 0.3335 0.3485 0.3730 25	0.3730	0.3730	-	25		10	20	0.0235	05100	0.3735	0.0005	18,830	
20         0.0235         0.0150         0.3730         Net         Fasteners failed; side plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate brown in the plate	2 0.335 0.3485 0.3730	0.3485		0.3730	.	_			0.0235	05:00	0.3735	9000		
20         0.0235         0.0150         0.3735         0.0005         17.240         Hd           20         0.0235         0.0150         0.3735         0.0005         17.240         Hd           20         0.0235         0.0150         0.3735         Net         Fasteners failed; side plate b           20         0.0235         0.0150         0.3735         Net         Fasteners failed; side plate b           20         0.0235         0.0150         0.3735         0.0005         i.3,750         Ma           20         0.0235         0.0150         0.3735         0.0005         i.3,750         Ma           20         0.0235         0.0155         0.3736         Ne;         Ma         Ma           20         0.0235         0.0155         0.3730         Ne;         Ma         Ma	3 0.3335 0.3485 0.3730 20	0.3730	0.3730	_	20		10	20	0.0235	0.0150	0.3730	Net		
20         0.0235         0.0150         0.3735         0.0005         17,240         CW         Hd           20         0.0235         0.0150         0.3735         Net         Fasteners failed: side plate b           20         0.0235         0.0150         0.3735         Net         CW         Hd           20         0.0235         0.0150         0.3735         0.0005         i.3.750         Hd           20         0.0235         0.0155         0.3735         0.0005         i.3.750         Hd           20         0.0235         0.0155         0.3730         Net         Hd         Hd           20         0.0235         0.0155         0.3730         Net         Hd         Hd	4 0.3335 0.3485 0.37.30			03730					0.0235	0.0150	0.3730	Net		Fasteners failed; side plate broke
20         0.0235         0.0150         0.3735         Net         Fasteners failed: side plate b           20         0.0235         0.0150         0.3735         Net         Fasteners failed: side plate b           20         0.0235         0.0150         0.3735         0.0005         i3.750         Wh           20         0.0235         0.0155         0.3735         0.0005         We:         Wh           20         0.0235         0.0155         0.3730         Net         Net         Net	1 0 7335 0 3485 0 3730 20	0.3730	0.3730		20		10	50	0.0235	0.0150	0 3735	0.0005	17.246	
20         0.0235         0.0150         0.3735         Net           20         0.0235         0.0150         0.3735         Net           20         0.0235         0.0150         0.3735         0.0005         13.750           20         0.0235         0.0155         0.3735         0.0005         20.0005           20         0.0235         0.0155         0.3730         Net         Net	2 0.3335 0.3485 0.3730			0.3730					0.0235	0.0150	0 3735	0.0005		¥. [-]
20         0.0235         0.0150         0.3735         Net           20         0.0235         0.0150         0.3735         0.0005         13.750           20         0.0235         0.0155         0.3735         0.0005         20.0005           20         0.0235         0.0155         0.3730         Net         Net	3 0 3335 0 3485 0 3735 25	0.3735 2	0.3735 2	~	25		10	20	0.0235	0.0150	0.3735	Net		
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20 00235 0.0155 0.3735 0.0005	1 0 3 3 3 5 0 3 4 8 5 0 3 7 3 0	0.3730	0.3730		50		10	20	0.0235	0.0150	0.3735	0 0005	13,750	-
20 0 0235 0 0 0 55 0 3730 0 0 2 3 5 0 0 1 5 5 0 3 7 3 0	2 0.3335 0.3490 0.3730			0.3730 -	-				0.0235	0.0155	0 3735	0.0005		110
0.0155 0.3730	3 0 3 3 3 5 0 3 4 9 0 0 3 7 3 0 2 9	0.3730	0.3730	 	20		10		0.0235	0.0155	0 3730	Ne:	į	
	4 0.0335 0.3490 0.3730			0.3730				i	0.0235	0.0155	0 3730	Net		

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180. to 240 · kip Riehle Los 600 cpm Materials D. Reese 300 M
high load transfer,
0.0002 clearance Hi-Lok,
0.020 micarta,
110 ksi 5 FATIGUE CONDITIONS Max test toad (kip) Max net stress (ks) Test lationatory Test frequency Load ratio (R) 0.002-0.0003 clearance Test machine Test engineer Ream, C/W, ream Hi Lok, prot hd 240.250 0.375 PHASE 11 - TASK 4 - APPLICATION AND PROCESS PARAMETERS DATE 11/17/73 FASTENER INSTALLATION Nominal hole size (in ) HOLE PREPARATION Torque fee the Proces SPECIMEN 623080 Type Ī Carbide (BAC 579) Push, no sleeve Fel Pro 300 0.3570 0 030 0.023 1657_4E2.__ Manchel max diameter (m) __ Mandret taper In (in ) Siegar thickness (in.) COLDWORK PROCESS Interference (in.) Skinge Orientation Manderl mater of Lubric Hon Steeve Lype 300 M (270 300 ksi) Shot peen Frg. 10 Shim thickness (in.) 0.020 0.750 0.250 1.50 3.00 SPECIMEN DESCRIPTION Hole spacing (in.) Material goge fini Surface treatment Edge margin lin ) Configuration Width (in ) Material

Origin of failure	and remarks							, }		***		)	
Cych-s	failure	14,850				21.820				17.150			
Fastener size (in.)	ij.	0 3735	0.3735	0 0030	0.0030	0.0025	0 0025	0.0020	0 0025	0 0025	0 0025	0 0000	0.0000
Fastener	Diameter	0 3735	0.3735	0.3735	0.3735	0.3735	0.3735	0.3735	0.3735	03730	0.3730	03730	0 3730
Солимовк екралмов (та.)	Retained	0.0150	0.0150	0.0150	0.0150	00100	05100	0.0150	0.0150	0.0150	0.0150	00100	0.0156
rio. Capin	Actua	0 0235	0.0235	0 0235	0 0235	0 0235	0 0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235
ā	After	75	:	30	-	ı	:	,		25.	. !	۶ ۱	- 1
Hole finish (RHR)	After	10		5	:	10	    - 	10		0	;	01	
Ha	Before coldwork	25	i	25		75	-	25		25		75	
_	Atter	0.3765	0 3765	0.3765	0 3765	0.3760	0.3760	0.3755	03760	0.3755	0.3755	0.3750	03750
Hoir diameter (in )	After	0.3485	0 3485	0.3485	0.3485	0 3485	0.3485	0.3485	0 3485	0.3485	0.3485	0.3485	0.3485
Į	Before	0.3335	0 3335	0 3335		0.3335	0.3335		0.3335	0.3335			İ
	ē s	-	2	3	4	-	2		4	-	ć.	m	-
Soecimen	200	4				5				9			

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PHASE II - TASK 4 - APPLICATION AND PROCESS PABAMETERS  high load transfer.    C.M. 0.002 interference, Hi-Lok	TEST4E3 SPECIMEN 623080 DATE 11/18/73 110 Ksi	PROCESS HOLE PREPARATION FATIGUE CONDITIONS	ce (in.) 0.023 Nominal note size ten 1 0.0325 Man net steess that 110	Push, no steeve Process Ream, C/W, ream Max 11-11 load (kip) 61	Library (m.)	Tred frequency 600 cpm	Carbide (BAC 5792) FASTENER INSTALLATION Trust into a total and a total and a total and a total and a total a total and a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a total a tota	aper (in in ) 0.030 Type Hi-Lok prot hd Test enqueer D Reese	nax diameter (in) 0.357 Fri (in.) 0.002 0.003 interference Test machine Rights, or	Fal Pro 300 +
PHASE II -TASK 4 <u>APPLICA</u>	463	COLDWORK PROCESS	Interference (in.) 0.023	Steever type	Sleeve thukness (m.)	Sleeve of entiation	Mandret material	Mandret taper (m.24)	<u> </u>	Ful Pro
		SPECIMEN DESCRIPTION	Configuration	300 M (270-300 Ksi)	3.00 Width (m.)	Hole spacing (in.) 1:50	Erdon margin (in ) 0.75	0.250	Surface treatment	0000

Origin of failure	and remarks	L Hd			•	H _Q				H	ine.		
Cycles	faiture	20,350				15,040				21,930	1		
Fastriner size (in )	į	0.002	0.002	0.002	0 005	200 0	0.002	0 0025	0 0025	0 0025	0.0025	0.0025	0.0025
Fastroe	Diameter	0.37.35	0.3735	0.3735	0 3735	0 3735	0 3735	0 3735	0.3735	0.3735	0.3735	0.3735	0.3735
Coldwork expansion (ii)	Hetamed	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150
Cote	Actual	0.0235	0.0235	0.0235	0 0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0735	0.0235
=	After	50		2		20		2		2		50	
Hole (mush (RHR)	After	10		01		01		02		01		01	
Ť	Bi-fore coldwork	2.5	I !   	25		25		25		75		25	
-	Athe	0.3715	03715	0.3715	0.2715	0.3715	0.3715	0.3710	0.3710	0.3713	0.3710	0 3710	0.3710
Hole diameter In 3	After	6.3485	0.3485	i	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485
Î	Selore coldwork	0 3335	0 3335	0 3335	0 3335	Ţ	i	•	0 3335		C.3335	C.3335	0.3335
	.ic.	-	~	, E	-	-	7	~	-	_	~		] -
	dysh on	_				20				6			

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300 M high load transfer, C/W, flush hd, Hi-Lok 0.020 micarta, 110 ksi

TEST_4E4 SPECIMEN_623080___0ATE__11/18/73

S	011	62	0.1	600 cpm	Materials	D. Reese	180 to 240 kip	
FATIGUE CONDITIONS	Max net stress (ks.)	Max test load (kip)	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
	0.375	Ream, C/W, ream, csk			NC	Hi-Lok, 1000 hd	Net to 0.0005 interference	240.250
HOLE PREPARATION	Nominal hole size (in.)	Process			Carbide (BAC 5792) FASTENER INSTALLATION	Type	Fit (in.) Net to 0	Torque (m. 1b)
	0.023	push, no sleeve	1		Carbide (BAC 5792)	0.030	0.357	Fel Pro 300
COLDWORK PROCESS	Interference (in.)	Sleeve type	Sleeve thic kness (in.)	Sleeve Orientation	Mandrel material	Mandrel taper (in /in )	Mandrel max diameter (in)	Lubrication
NOIT	Fig. 10	300 M (270-300 ksi)	3.00	1.50	0.750	0.125 side plates, Material gage (in ) 0.250 center	Shot peen	in.) 0.020
SPECIMEN DESCRIPTION	Configuration	Material 30	Width (in )	Hole spacing	Edge margen (in )	Material gage (in )	Surface treatment	Shim thickness (in.) 0.020

Origin of failure	and remarks	→ Had			Side plates failed	+ 7			Side plates failed	+ =			Side plates failed
Cycles	failure	7,910				8,090				9,300			
Fastener size (in )	n.	Net	Net	Net	Net	0.0005	Net	0.0005	0.0005	Set	0 00005	0 0005	0 00005
Fastene	Diameter	0.3735	0.3735	0.3735	0.3735	0.3735	0.3730	0.3735	0.3735	0.3735	0 3735	0.3735	0.3735
Coldwork expansion (in )	Retained	0.0153	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150
Colc	Actual	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235
	Aher ream	20	1	20	!	20	-	20			1	1	-
Hole funsh (RHR)	After coldwork	10		01	i	10	į	10	1	15	1	15	:
Ĭ	Before	25	1	25	į	25	ı	25	1	30		30	1
	After	0.3735	0.3735	0.3735	0.3735	03730	0.3730	0 3730	03730	0.3735	03730	03730	03730
Hole diameter (in.)	After	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485
Jo H	Before	0.335	0.3335	0 0335	C 3335	0.3335	0.3335	t.3335	0.3335	0.3335	0.3335	0.3335	0.3335
	e o	-	2	3	4	_	2	ا ا س	4	-	2	3	4
Specimen	nseb on	01-				=				12			

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110 ksi		ss (ks.i) 110 and 95	Max test load (kip), 54 (95), 62 (110)			Materials	, D. Reese	Richle Los	•
110 ks	FATIGUE CONDITIONS	Max net stress (ksi)	Max test los	Load ratio (R)	Test frequency	Test laboratory	Test engineer	Test machine	
SPECIMEN 623080 DATE 11/12/73	HOLE PREPARATION	Nominal hole size Inc.) 0.375	Process			FASTENER INSTALLATION	Type	Fit (in,) Net to 0.0005 clearance	Torque (in 1b) 240.360
TESTSPECIMEN								er (m)	
1E.	COLDWORK PHOCESS	Interference	Sleeve type	Steeve thickness (in.)	Sleeve or entation	Mandrel material	Mandrel taper (in /in )	Mandrel max diameter (iii )	Lubrication
	SPECIMEN DESCRIPTION	Configuration Fig. 10	300 M (276-300 ks!)	Width (in )	Hole spaceing	Edgy margin (in ) 0.75	Material gage lin ) 0.250	Surface treatment	Shim Thickness (in.) 0.020
	SPE	J	-	-	_	_	_	2,	-

Origin of failure	and remarks	-			110-ksi load				95 ksi load	- I			95-ksi load
Cycles	fanore	4,220				8,040				9.320			
10 Ja (10)	F.1	Net	Net	Net	Net	Net	Net	Net	Net	Net	Net	Net	Net
Fastener size (in )	Diameter	0.3735	0.3735	0 3735	0.3735	0.3735	0.3735	0.3735	0.3735	0.3735	0.3735	0.3735	0.3735
Coldwork expansion (in )	Retained												
Cold	Actual					-							
н)	After	25	,	25	-	25	-	25	-	25		25	:
Hole finish (RHR)	After		1										
Ĭ	Before												
_	After												
Hote dameter (in l	Atter												
Hol	Before	0.37.35	0.37.35	3.3735	0.3735	0.3735	0.3735	0.37.35	0.3735	0.3735	0.3735	0.7335	0.3735
1	10 P	-	2	3	4	-	2	6	4	-	2	3	4
Commission	dest on	.13				1.4				15			

PHASE II - TASK 4. APPLICATION AND PROCESS PARAMETERS

SPECIMEN 623080 DATE 11/15/73

1EST 4E6

300 M C/W, net fit Hi-Lok. no micarta 110 ksi

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s 122	72.5	0.1	600 cpm	Materials	D. Reese	180 to 240 kip Righte Los	
FATIGUE CONDITIONS Max net stress (ks)	Max test load (kip) 72.5	Load ratio (R)	Test frequency	Test faboratory	Test engineer	Test machine	
0.375	Ream, C/W ream			TION	Hi Lok, prothd	Net to 0.0005 clearance	240 250
HOLE PREPARATION Nominal hole size (in 1	Process			Carbide (BAC 5792) FASTENER INSTALLATION	Type	Fit (in.) Net to	Torque (in Iti)
0.023	Push no sleeve	1	ł	Carbide (BAC 579	0.030	0.357	Fet Pro 300
COLDWORK PHOCESS	Sheve tysk	Steeve thickness (in.)	Strive Orientation	Manifed material	Mandrel taper fin 'no )	Mandrel max diameter (m.) 0.357	Lubrication
71.0N Fig. 10	300 M (270 300 ks)	3.00	1.50	0.75	0.250	Shot peen	
SPECIMEN DESCRIPTION	Material 300	Width (in )	Hote specing (in.)	Edge margin (in )	Material gage (in )	Surface treatment	

Origin of failure	and remails	Cw Hol				± ±			Fasteners failed	H			Fasteners failed
Cycles	favore	7,150				9,660				11,770			
Fastener size (in )	۶ با	Net	Net	Net	Net	Zer	Net	Net	Net	Net	Zet	Nei	Net
Fastener	Olameter	0 3735	0.3735	0 3735	0.3735	0.3730	0.3730	0.3730	0.3730	0.3740	0 3735	0.3735	0.3735
Coldwork expansion iin l	Retained	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0145	0.0145	0.0150	0.0150
Cold	Actual	0 0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0735	0.0235	0.0230	0.0230	0.0235	9.0235
_	Alter	20		20		20	-	20		2		<u>م</u>	
Hore finish (RHR)	After coffwork	10		10	:	10	.   	10	-	10		10	
£	Before	20		25	1	20		20	-	30	į.	35	
	After	0.3735	0.3735	0.3735	0.3735	0.3735	0.3730	0.3730	0.3730	0.3740	0.3735	0.3735	0.3735
Hole (hameter fin.)	After coldwork	0.3485	0.3485	0.3485	0.3485		0 3485	0.3485	0.3485	0.3485	0.3485	0.3485	0.3485
H	Rufore	0.3335		0,3335	0.3335	0.3335	0.3335		0.3335		l	0 3335	ļ
	i e	-	2	3	4	-	2	3	4	-	2	en	6
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STRAIN GAUE READINGS AND CALCULATED STRESSES-STEEL

r		Reamed only ingt area - 0.4351	ingt area	· 0 435					Š	tworked in	Coldworked (ner area = 0.430)	430			Œ	Reamed after coldwork (net area - 4 10)	v coldwor	t inet area	. 4 10;			Ž	Mim Doits Astalled	Zered Zered		
											Strain Is.	Strain fapplied load	E .:													
	#	1 0	7	8	89	•	٥	3	0	12	24	98	84	۰	٥	12	34	98	3	•	0	12	7.	×	*	•
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	161.3	485 GR	2 402	2 329%	4 200	56	9	0 4,360	0 477	1,540	2.508	3,438	4,371	479	480	1,560	2,535	3,495	4,445	689	864	1 532	2.498	3,435	***	513
						_		_	6	1,374	2,256	3,140	0.04	552	\$14	1,369	2,281	3,202	4,125	53	576	1,375	2 268	3 165	103	8
							_	3,510	178	8	1,700	2,600	3,515	.176	-164	838	1,756	7,684	3,618	-153	- 165	815	1 727	2636	<b>9</b>	9
							_	_	2 813	1,532	2,353	3.198	4,076	817	778	2,5	2,395	3,279	67.7	162	797	1,514	2 351	3217	4 105	8
							_		3 1,943	2,926	3,800		5.471	1,945	1,870	2,806	3,672	4.518	5,346	1,827	1.862	2.825	3 705	188	987.5	8
	, ,,									3.754	4.592	5,395	6,191	2.820	2.748	39.	**68	5.276	6.064	2.711	2,769	3,700	542	937.5	6.165	32
								3,435	5		1,845	2.648	3,442	- 20	128	1,026	1.851	2,662	3.455	123	119	1 020	1.850	2,652	3442	2
	ł	1									Cal. Jates	Cal. Jisted theoretical stress, psi	al stress, p	3												
	35, 721.0	63.2 10		2 82 7	SHE 011   657 59   CT   10 345	_	0	0 111 628	_	0 27,907	7 55,814	L.,	83.721 111.628	0	0	29 266	58,537	87.805	117 073	٥	٥		1	-		
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## COST STUDY

Elemental Flow Times	Norm	nal man-minu	ites
Positioning -Hand drill Hand reamer Winslow drill Quackenbush drill Taperlok reamer Torque tool		0.03 0.02 0.08 0.16 0.06 0.05	
	AL	<u>Ti</u>	SH
Drilling-Hand drill Winslow drill, regular hole (6000) Winslow drill, Boeing PT bolt hole (HS-2) Winslow drill, Taperlok hole	0.32 0.18 0.10 0.19	<del></del>	
Quackenbush drill	-	0.62	3.1
Reaming—Manual, straight hole Manual, tapered hole Quackenbush, straight hole Quackenbush, tapered hole Pin ream, tapered hole	0.04 0.16 - - 0.15	- 0.84 0.334 0.20	0.84 1.05 0.20
Bolts/nucs -Insert Drive Boeing PT bolt	0.06 0.086	0.06	0.06
Drive Taperlok Inspect protrusion (Taperlok) Place nut Torque nut, regular Torque nut, HiLok Primer/scalant	0.08 0.08 0.43 0.05 0.07 0.025	0.12 0.08 0.43 0.05 0.07	0.15 0.08 0.43 0.05 0.07
Inspection—Inspect regular hole Inspect PT hole Inspect tapered hole Inspect flushness Inspect C/W hole	0.02 0.04 0.12 0.03 0.04	0.02 0.04 0.36 0.03 0.04	0.10 0.04 0.40 0.03 0.04
Coldworking—Place sleeve Insert and pull Remove sleeve Lubricate and bake Push or squeeze mandrel	0.065 0.050 0.02	0.065 0.050 0.02	0.10 0.16

### Process Times and Costs (at \$10.50/hr)

### Normal man-minutes

1) Taperlokprotruding head	<u>Aluminum</u>	Titanium	Steel
Prorated setup and sample plates	0.236	0.69	0.82
Position drill	80.0	0.16	0.16
Drill straight hole	-	0.62	3.10
Drill/csk tapered hole	0.19		***
Position reamer	<del>-</del>	0.16	0.16
Ream taper	*-	0.334	0.105
Inspect hole	0.12	0.36	0.40
10% pin ream	0.015	-	
100% pin ream	-	0.20	0.20
Insert bolt	0.06	0.06	0.06
Inspect protrusion	0.08	80.0	0.08
Drive bolt	0.08	0.12	0.15
Install nut	0.43	0.43	0.43
Torque nut	0.05	0.05	0.05
Inspect flushness	0.03	0.03	0.03
14% PF&D*	0.192	0.468	0.80
Total normal man-minutes	1.563	4.210	6.545
Labor cost	\$0.274	\$0.735	\$1.14
Cutter cost/hole-drill	0.03	0.015	0.135
Cutter cost/hole—Taperlok reamer		0.11	0.84
Total installation cost	\$0.304	\$0.86	\$2.115
Steel Taperlok pin \$0.54			
Titanium Taperlok pin 0.97			
Steel nut 0.07			
Titanium seal nut 0.43			
Total costs/installation	Aluminum	Titanium	Steel
Steel Taperlok and steel nut	\$0.91	\$1.47	\$2.73
Steel Taperlok and seal nut	1.27	1.83	3.09
Titanium Taperlok and steel nut	1.34	1.90	3.16
Titanium Taperlok and seal nut	1.70	2.36	3.52

^{*}Personal fatigue and delay

## 2) Coldworked holes with titanium Hi-Loks-protruding head

	Non	<u>nal</u> man-min	utes
	Aluminum	<u>Titanium</u>	Steel
Prorated setup	0.110	0.110	0.25
Position drill	-0.08	0.110	0.23
Drill straight hole	0.10	0.10	3.10
- Inspect hole—sample	0.01	0.02	0.01
Place sleeve on mandrel	0.065	0.065	0.01
Insert and pull	0.050	0.050	
Remove sleeves	0.030	0.030	
Drylube hole			0.10
Place aligner on mandrel	*.*		0.10
Insert mandrel	_	-	0.03
Position part on yoke and push	_	_	0.16
Inspect hole	0.02	0.02	0.02
Position reamer	·-	0.16	0.16
Postream	0.04	0.84	0.84
Insert bolt	0.06	0.06	0.06
Place nut	0.43	0.43	0.43
Torque nut	0.07	0.07	0.07
14% PF&D	0.147	0.376	0.76
Total normal man-minutes	1.202	2.991	6.17
Labor cost	\$0.21	\$0.523	\$1.08
Cutter cost/hole-drill	_	0.015	0.135
Cutter cost/holeream		0.021	0.21
C/W sleeve cost	0.14	0.14	
Mandrel cost		-	0.30
Total installation cost	\$0.35	\$0.699	\$1.725
Titanium Hi-Lok pin 0.31			
Aluminum collar 0.05			
Aluminum seal nut 0.14			
Total costs/installation	Aluminum	Titanium	Steel
C/W holes with titanium Hi-Lok plus aluminum collar	\$0.71	\$1.06	\$2.09
C/W holes with titanium Hi-Lok plus	0.00		
aluninum seal nut	0.80	1.15	2.18

## 3) Coldworked holes with steel lockbolts and 10% steel Hi-Loks

,		<u>Norr</u>	nal man-mini	utes_
<del></del>		Aluminum	<u>Titanium</u>	Steel
Prorated setup		0.110	0.110	0.25
Position drill		0.08	0.16	0.16
Drill straight hole		0.10	0.62	3.10
Inspect hole-sample		0.01	0.01	0.01
Place sleeve on mandrel		0.065	0.065	-
Insert and pull		0.050	0.05	_
Remove sleeves		0.02	0.02	_
Drylube hole			_	0.10
Place aligner on mandrel				0.02
Insert mandrel		-	_	0.03
Position part as yoke and push		-		0.16
Inspect hole		0.02	0.02	0.02
Position reamer		0.01	0.16	0.16
Postream		0.04	0.84	0.84
Insert lockbolt-90%		0.054	0.054	0.054
Place collar-90%		0.02	0.02	0.02
Pull lockbolt and swage collar-90%		0.07	0.07	0.07
Insert Hi-Lok-10%		0.006	0.006	0.006
Place nut-10%		0.043	0.043	0.043
Torque nut-10%		0.007	0.007	0.007
14% PF&D		0.099	0.315	0.705
Total normal man-minutes		0.804	2.570	5.755
Labor cost		\$0.14	\$0.45	\$1.01
Cutter cost-drill			0.015	0.135
Cutter cost-reamer			0.021	0.21
C/W sleeve cost		0.14	0.14	
Mandrel cost			-	0.30
Total installation cost		\$0.28	\$0.626	\$1.655
Steel lockbolt pin \$0.09				
Aluminum seal collar 0.03				
Steel Hi-Lok pin 0.17				
Aluminum seal nut 0.14				
Total installed costs		Aluminum	Titanium	Steel
C/W noles with 90% steel lockbo	olts,			
10% steel Hi-Loks		\$0.42	\$0.77	\$1.80

## 4) Interference-fit straight-shank bolt

		Norr	nal man-min	utes
		Aluminum	Titanium	Steel
Prorated setup and sample plate	25	0.19	0.36	-
Position drill		0.08	0.16	•
Drill straight hole		0.10	0.62	_
Position reamer		_	0.16	_
Ream		_	0.84	
Inspect sample		0.04	0.04	_
Insert bolt		0.06	0.06	_
Drive bolt		0.08	0.12	_
Place nut		0.43	0.43	
Torque nut		0.07	0.07	-
14% PF&D		0.147	0.40	
Total normal man-minute	s	1.197	3.26	
Labor cost		\$0.21	\$0.57	
Cutter cost/hole-drill		_	0.015	
Cutter cost/hole-reamer		-	0.021	
Total installation cost		\$0.21	\$0.606	
Interference-fit titanium pin	0.34			
Aluminum collar	0.05			
Aluminum seal nut	0.14			
Total costs/installation		Aluminum	Titanium	Steel
Interference-fit titanium p	oin with			
aluminum collar		\$0.60	\$1.00	_
Above with aluminum sea	l nut	0.69	1.09	

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13. ABSTRACT				

In this 21-month program, optimized process parameters for sleeve coldworking of fastener holes have been developed, and the effects of process and application parameters on structural performance have been defined for selected aluminum, titanium, and high-strength steel alloys. The sleeve coldworking process for fastener holes is a process that uses a tapered mandrel in conjunction with a disposable, prelubricated sleeve to compressively prestress a significant size zone around each hole which offsets the stress concentration of the hole itself. The sleeve method allows higher degrees of prestressing than possible with other methods and offers potential for significant improvements in fatigue performance. In addition, it does not require precision controls germane to other fatigue-rated hole preparation/fastener installation systems. This technical report covers the results of this 21-month program. In addition to definition of optimized methods and the effects of process and application variations upon structural performance, the results include performance and economics comparisons for the process with other fatigue-rated hole preparation/fastener systems.

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Prestressing						
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